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ENGLAND & WALES

WELLS AND SPRINGS OF WORCESTERSHIRE

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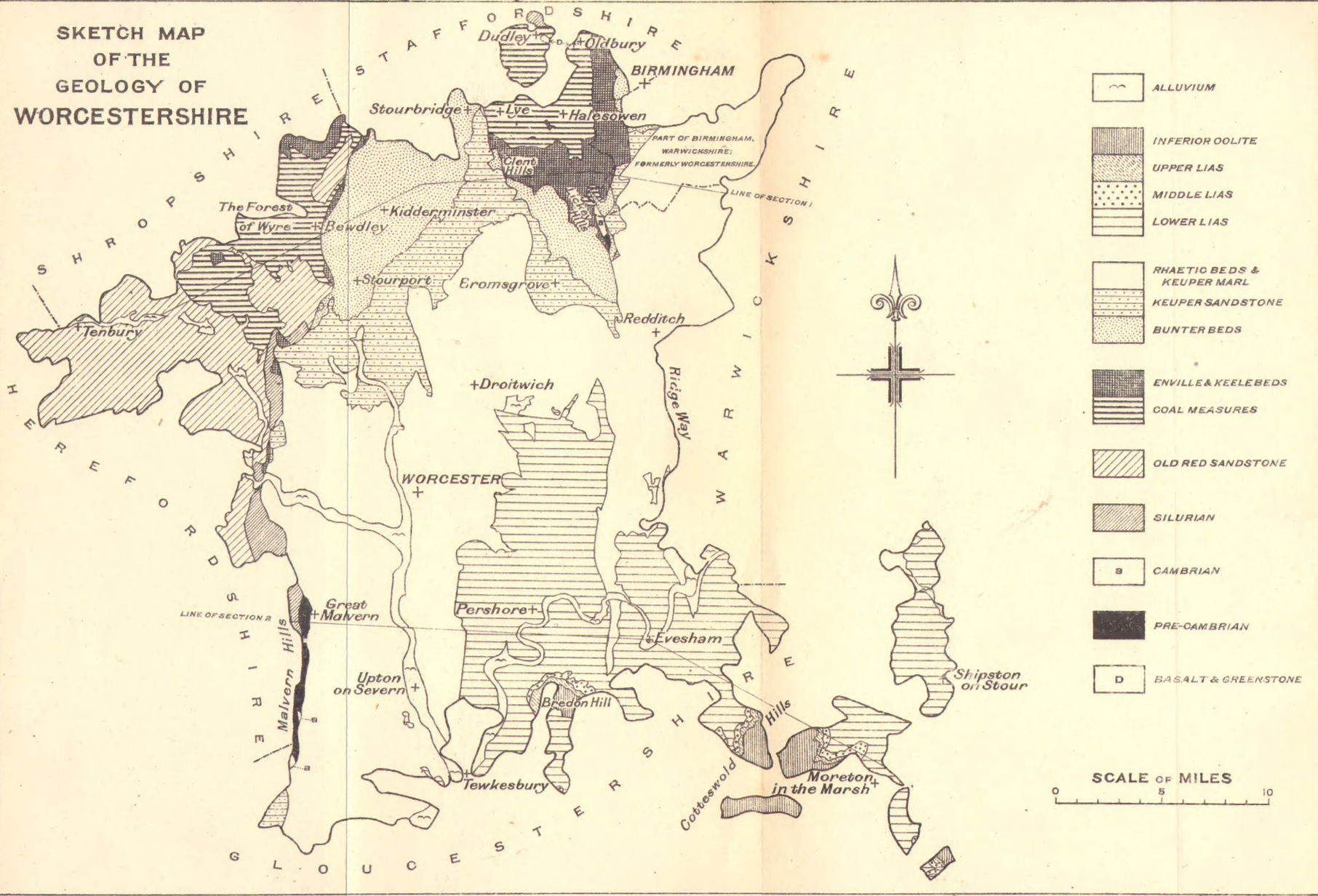
SKETCH MAP OF THE GEOLOGY OF WORCESTERSHIRE



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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

MEMOIRS OF THE GEOLOGICAL SURVEY ENGLAND & WALES

Wells and Springs of Worcestershire

By

L. Richardson, F.R.S.E., F.G.S.

With contributions by Cecil Cooke Duncan, F.I.C., F.C.S. and B. Brotherton, F.R.G.S.

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PREFACE

The present memoir is the twenty-third volume of a series, now being published by the Geological Survey, which deals with the water supplies of the counties of England from underground sources.

The preparation of the volume on Worcestershire, as of those of the neighbouring counties of Gloucestershire and Warwickshire, has been entrusted to Mr. L. Richardson of Birmingham, who possesses a wide and expert knowledge of local geological detail, and a familiarity with this part of the Midlands that extends over many years. The value of the information here collected by the author has been enhanced by the addition of an exceptionally large number of analyses made by Mr. C. C. Duncan, F.I.C., F.C.S., County Analyst, who has also written an introduction to this section of the book, and by the paragraphs treating of the rainfall, which are contributed by Mr. B. Brotherton, F.R.G.S.

Though supplies from wells and springs are the particular subject of the memoir, waters of superficial derivation are sometimes brought into use, and it has been deemed advisable in certain instances to include some account of these.

Our acknowledgments are due to all who have supplied particulars of wells, springs and borings.

The memoir has been edited for the press by Mr. C. H. Dinham.

JOHN S. FLETT,
Director.

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LONDON, S.W.1.

11th December, 1929

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WELLS & SPRINGS OF WORCESTERSHIRE

I.—INTRODUCTION

Worcestershire ranks thirty-third in size among the counties of England and Wales, having an area of 751 square miles, of which 40 belong to ' detached ' areas lying outside the main portion.

West of a sinuous, more or less north and south, line running from some 4 miles N.N.W. of Kidderminster, past Bewdley, and east of Stagbury, Abberley, Woodbury and the Malvern Hills, and again in the neighbourhood of the Clent and Lickey Hills, the land-relief is very varied. The Malvern Hills culminate in the Worcestershire Beacon, 1,395.2 ft. above Ordnance Datum, Woodbury Hill is 904 ft. high ; Abberley Hill, 779 ft. ; Clows Top, near Rock, 724.9 ft. ; Walton Hill, a peak of the Clent Hills, 1,036 ft. ; and Beacon Hill, in the Upper or Bromsgrove Lickey Hills, 956 ft.

The remainder of the county—except for Bredon Hill, 977.6 ft., and Broadway Hill (the second highest point of the Cotteswold Hills), 1,031.3 ft.—is lowland, below 400 ft. above O.D., and in it are Evesham, Worcester, Droitwich, Kidderminster, Bromsgrove and Redditch.

The Malvern Hills are composed of Archaean rocks ; but otherwise, except for some very small Archaean inliers, the western area of very varied land-relief, described above, is on Palaeozoic rocks. All the rest of the county—including Bredon and Broadway Hills—is floored with younger, Neozoic, rocks.

The lines of demarcation between the Archaean and Palaeozoic rocks and between these and the Neozoic rocks, are for the most part faults. Those which form a more or less continuous line from N.N.W. of Kidderminster to the southern end of the Malvern Hills, by letting down the Neozoic rocks on the east, have had an important effect on the land-relief.

Palaeozoic and probably, locally, Archaean rocks, underlie the whole expanse of Neozoic ; but, except quite close to their occurrence near the surface, these older rocks have not been proved beneath the newer by borings actually within the county. In Gloucestershire, however, near Moreton in Marsh, and just beyond the eastern boundary of Blockley parish, Worcs., a boring at Lower Lemington, proved [1] :—

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
Neozoic	Lower Lias	418	0	418	0
	Rhaetic with White Lias ...	48	6	466	6
	Keuper with Tea-green Marl ...	481	0	947	6
	Lower Keuper Sandstone ...	74	0	1,021	6
Palaeozoic	Coal Measures (Upper) ...	524	6	1,546	0
	Silurian	154	6	1,700	6

[1] The boring (sometimes called Batsford boring) was in Field No. 45, near brooklet, 350 yds. W.N.W. of Lower Lemington church, Glos., and within half a mile of the Fosse Way, which here makes the eastern boundary of Blockley parish, Worcs. Surface level, about 380 ft. above O.D. For further details see ' Summary of Progress ' for 1912 (*Mem. Geol. Surv.*), 1913, pp. 90, 91.

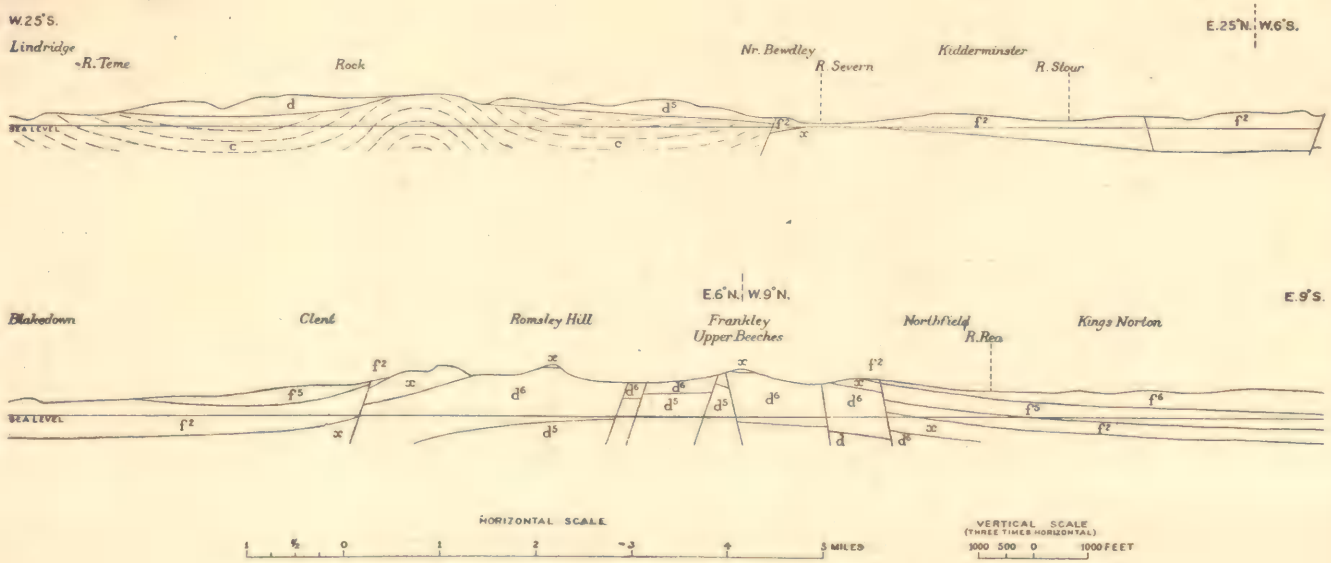

FIG. 1.—*Section (No. 1 on map) from Lindridge to Kings Norton, Birmingham.*

c, Old Red Sandstone. d^5, Middle Coal Measures. d, Transition Coal Measures.
d^6, Upper Coal Measures. x, Clent Breccia. f^2, Bunter.
f^5, Lower Keuper Sandstone. f^6, Keuper Marl.

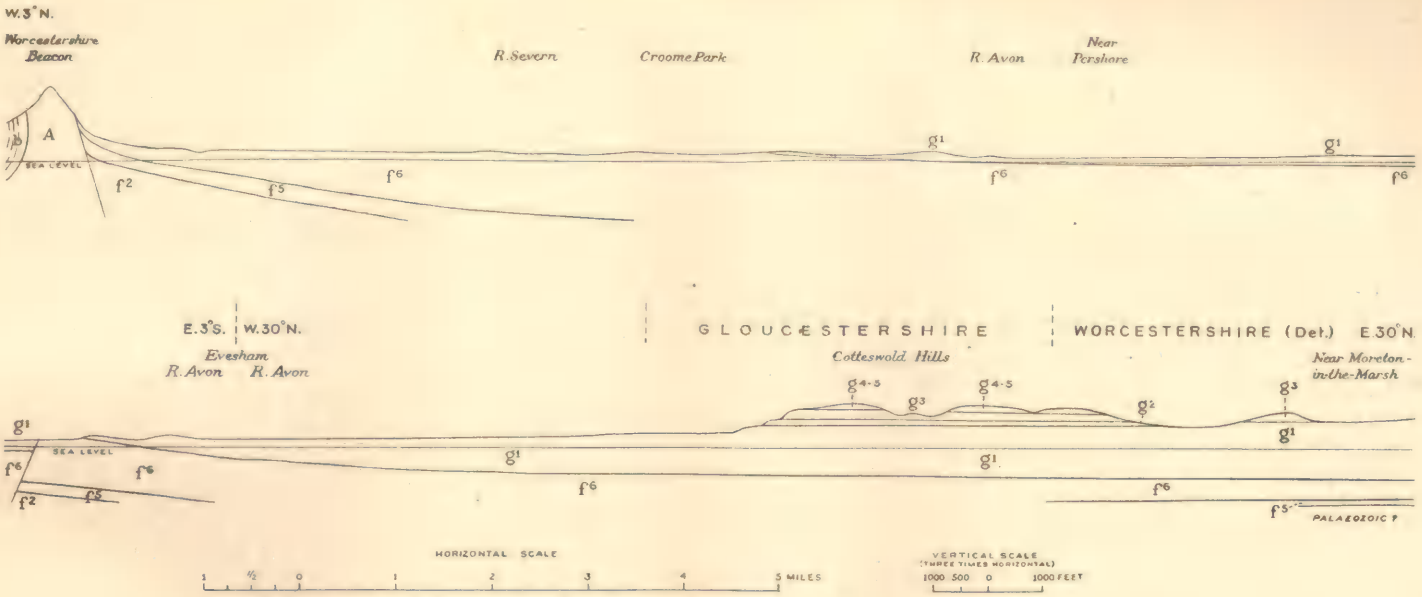

FIG. 2.—*Section (No. 2 on map) from Great Malvern, through Evesham, to Moreton in Marsh.*

A, Pre-Cambrian. b, Silurian, faulted against Pre-Cambrian. f^2, Bunter.
f^5, Lower Keuper Sandstone. f^6, Keuper Marl and Rhaetic. g^1, Lower Lias.
g^2, Middle Lias. g^3, Upper Lias. g^{4-5}, Inferior and Great Oolite.

Reference to a geological map will show that the Neozoic rocks of the county have been gently folded into broad synclines and anticlines. The main syncline, so far as this county is concerned, starts between the Palaeozoic rocks west of Kidderminster and those forming the southern end of the South Staffordshire Coalfield (see Fig. 1), and newer rocks come on in this syncline as a traverse is made from N.N.W. to S.S.E., roughly speaking, until the youngest solid rocks are encountered on the top of Bredon Hill. Another syncline runs more or less southwards from between the southern end of the South Staffordshire Coalfield and the Warwickshire Coalfield ; but only a small portion of the county comes into this syncline. Between the axes of these two main synclines, minor folds may be noticed in the neighbourhood of Evesham.

Distributed over the greater portion of the county are relics of the Glacial Period in the form of boulder clay, sand and gravel ; while sands and gravels that have been arranged by the rivers in their earlier days occur not far distant from the present courses.

Rivers

By far the greater part of Worcestershire is situate in the Severn basin ; only relatively small portions lie in the basins of the Trent and Thames.

THE SEVERN SYSTEM

The River Severn enters Worcestershire at Arley Quarry Landing. The distances from this point are : to Upper Arley Ferry, 1½ miles ; to Tewkesbury Bridge, 37⅝ miles ; to confluence with Avon, 38 miles. The fall of the river in the 12 miles from Stourport to Worcester is about 23 ft., and in the 28 miles from Worcester to Gloucester about 10 ft.

High water, on Spring Tides, occurs at Tewkesbury 3 hrs. 45 min., at Upton-on-Severn 4 hrs. 30 min., and at Diglis Locks [1] 5 hrs. 10 min. after Avonmouth, Glos.

Owing to the difficulty of navigating the gravelly fords of the Severn in summer, a Board of Severn Commissioners was formed and empowered by Act of Parliament, passed in 1842, to construct locks and weirs at Lincomb, Holt, Bevere (" Camp "), and Diglis, and to deepen the bed of the river below Worcester by dredging. The weirs and locks were constructed by Cubitt and E. Leader Williams and opened in 1844.

In 1853 an Act gave powers to construct the Upper Lode lock and weir which were opened in August, 1858, and an Act of 1890 empowered the Severn Commissioners to dredge the river to a greater depth than previously and to make alterations to the locks of 1844—work which was carried out under the direction of H. J. and E. D. Marten, the Commissioners' Engineers.[2]

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[1] At high Spring tides and under favourable conditions the tide has caused a rise of 10 in. on Diglis lower sill.

[2] See E. J. Bradley, *Trans. Worcs. Nat. Club*, vol. vi, pt. 5 for 1916 (1917), p. 237.

Average Yearly Rainfalls and Discharges [1] *in Severn Basin.*

Year	Rainfall : cubic feet per second	Discharge : cubic feet per second	Discharge as per cent of Rainfall	Loss due to absorption, etc. : cubic feet per second
1882 ...	6,354	3,249	51.2	3,105
1883 ...	4,935	2,229	45.2	2,706
1884 ...	4,170	1,779	42.6	2,391
1885 ...	4,932	2,152	43.6	2,780
1886 ...	5,806	2,779	47.9	3,027
1887 ...	3,514	1,615	46.0	1,899
1888 ...	4,277	1,889	44.2	2,388
1889 ...	4,490	2,056	45.6	2,434
Mean ...	4,807	2,218	46.2	2,604

The River Severn, according to an estimate by E. D. Marten and G. W. Keeling, engineers to the Severn Navigation (Report of the Royal Commission on Canals and Waterways, 1910-11), has a minimum flow at Lincomb weir, about a mile south of Stourport, of 24,550,000 cubic feet per twenty-four hours, which is about 153 million gallons per day ; while at Diglis weir, Worcester, it is 26,150,000 cubic feet or about 163½ million gallons a day. An exhaustive investigation of the flow of the Severn at a line a mile above Diglis weir, from gaugings taken between the years 1882 and 1889 inclusive, was published in 1916,[3] and the figures therein given may be taken as the most reliable for our present purpose :—

	Million gallons per 24 hours.
The average discharge was	1,206
The lowest summer discharge was	497
The lowest monthly discharge (August, 1884) was	270

The curve showing the daily discharge from 1882 reveals no gauging anything like so low as the 163 million gallons given by the engineers to the Severn Navigation, and it is safe to assume that the minimum discharge is well above 200 million gallons a day at Worcester, and probably above that figure also at Stourport, below the junction with the river Stour. At Tewkesbury, below the mouth of the Avon, the minimum flow of the Severn would be half as much again as at Stourport, or well over 300 million gallons a day, for the engineers to the Severn Navigation estimate the flow at Gloucester as 330 million gallons a day, and there are no tributaries of consequence between Tewkesbury and Gloucester.

Quality of the Severn Water.—An average of forty-two analyses of Severn water at Worcester gives 3.62 parts of suspended matter and 33.25 parts of dissolved solids in 100,000. Assuming that these dissolved solids consist of the average amount of carbonates, the average hardness of the water may be estimated at about 13°.[4] We may, therefore, conclude that the water, provided the solids (such as vegetation swept down during floods) are properly strained off, is quite suitable both for condensing and boiler feeding.[5] Recent surveys show that the water holds a satisfactory amount of oxygen.[6]

[1] At a point 1 mile above Diglis Weir at Worcester. This table is from Dr. J. S. Owens' paper (in 'The Investigation of Rivers—Final Report,' *Roy. Geogr. Soc.*, London, 1916) with a small correction.

[2] Area of Severn Basin, above the same point, was calculated as 1,970.67 sq. miles.

[3] "The Investigation of Rivers," *op. cit.*

[4] This estimate may be too high, for the total hardness of the water for the supply of Worcester is returned as 7.4°.

[5] *Engineer* (London), 1920, p. 647.

[6] River Pollution and Fisheries. *Ministry Agric. and Fisheries.* Third report, 1926, p. 9.

TRIBUTARIES ON THE RIGHT BANK OF THE SEVERN

Bushley Brook, rising in The Gullet between the Swinyard and Hollybush peaks of the Malvern Hills, with tributaries Longdon Brook and Marlbank Brook, whose head-waters have been impounded in The Camp Reservoir (Malvern U.D.C. Waterworks), which has therefore to provide compensation water.

Pool Brook with tributary Mere Brook.

Madresfield Brook with tributary Whiteacres Brook.

Carey's Brook with tributary Whippets Brook.

River Teme with principal tributaries (in Worcestershire) Kyre Brook, Spout Brook, River Rea, Sapey Brook, Leigh Brook and Laughern Brook. Above Knightsford Bridge, the Worcestershire ground drained by the Teme and its tributaries is nearly all on the Old Red Sandstone ; below, on the Keuper Marl. In the Old Red Sandstone country springs issuing from the Birch Hill Limestones are heavily laden with bicarbonate of lime which they deposit to form travertiné. Thus travertine forms in the Spout Brook wherever the brook goes over a fall or rapid,[1] and at " The Paradise " on the Sapey Brook where there is a lofty height called the " Hoar Stone " from which issue springs that encrust with calcareous matter the mosses over which their waters trickle.[2]

The Teme varies much in volume. An Electric Power Station was erected on it in 1894 at Powick but has not given complete satisfaction owing to the river now and again banking up, on which occasions there is no pressure to run the turbines. The average output is 750,000 units (kilowatt-hours) per annum.

Grimley Brook.

Shrawley Brook.

Dick Brook, whose course above Dick Bridge (on the Stourport-Great Whitley road) is for the most part over Old Red Sandstone, and below, over Lower Keuper Sandstone, in which its valley is deeply sunken. At Astley it is " stanked " [3] back for mill purposes.

Gladder Brook, enters the Severn between Areley Kings and Stagbury Hill and drains country floored with Coal Measures and Old Red Sandstone.

Dowles Brook drains the central portion of the Forest of Wyre Coalfield.

TRIBUTARIES ON THE LEFT BANK OF THE SEVERN

The (*Stratford*) *Avon River*, with tributaries the (Warwickshire) Stour, River Isbourne, River Arrow, Piddle (or Wyre) Brook, and Bow (or Besford) Brook.

The stretch of the River Avon from Evesham to Tewkesbury, where it joins the Severn, is 28 miles 2 furlongs long, and there are nine locks. It ceased to be navigable above Evesham about 1873,[4] and now portions below the town are obstructed by shoals and sedge banks.

Prof. W. S. Boulton says :—" . . . the river Avon at Leamington has a minimum flow of 31,000,000 gallons in twenty-four hours. The Royal Commisssion on Canals and Waterways, in their report for 1909-1910, proposed to abstract one third of this minimum flow of the Avon for canal purposes, or more precisely, 35 per cent, of the flow in the driest month in the minimum year, and 7 per cent in the driest month in a mean year." [5]

The Avon has been considered as an additional source of supply to Cheltenham, and more seriously, to provide water for Pershore, but the proposal was rejected on account of pollution.[6] In addition, the water tends to be hard, owing to its having come off mainly Keuper Marl and Lower Lias.

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[1] Lees, Edwin, " Pictures of Nature . . . around the Malvern Hills " 1856, p. 247.

[2] *Ibid.*, pp. 249—250 ; *Trans. Worcs. Nat. Club*, vol. for 1847—96 (1897), p. 71.

[3] *I.e.*, ' staunched,' or dammed.

[4] At Evesham, during the abbacy of Oswald (c. A.D. 960), a seal was taken in the Avon not far from the bridge. *Lelandi Collectanea*, t.I, p. 300.

[5] *Engineer*, 1920, p. 647.

[6] Marten, E. B., Report on the Water Supply for the Town of Pershore. 28th August, 1894.

According to analyses made by E. W. T. Jones, the permanent hardness of the Avon at Wyre Piddle is 17.48° ; of the Wyre Brook, 54.20° ; and of the Walcot Brook, 31° (analyses 645, 647, 648.

The Avon Commission of Sewers, which was established in 1892, exercises certain control over the Avon from Pershore to its confluence with the Severn. It has power to levy a rate on land subject to flood, and its object is to prevent flooding of the land adjoining the river during the spring, summer and autumn. It secures information that the river is rising when the sluices are opened, and claims that summer floods have been prevented.

The River Arrow, which enters the Avon at Salford Priors, Warwickshire, rises in the east side of Beacon Hill, in the Upper or Bromsgrove Lickey Hills, flows through a series of cement-bottomed pools in the grounds of the Old Rose and Crown Inn (City of Birmingham public park), through " Rednal Gap " and Cofton Hackett Reservoir, by the side of Upper Bittell Reservoir, and through Lower Bittell Reservoir, Alvechurch, and into Warwickshire near Ipsley, east of Redditch. Locally, the Arrow floods considerably.

The Warwickshire Stour, which rises on the uplands of North Oxfordshire, at Stour Well, Tadmarton, joins the Avon a mile or so below Stratford-upon-Avon. With the exception of a small portion of the parish of Blockley it drains the Worcestershire parishes in the Shipston-on-Stour Rural District ; but sometimes in dry periods no water flows in the course at the bridge at Clifford Chambers.

Hatfield Brook.

Duck Brook.

River Salwarpe, with tributaries Spadisbourne, Hen, Salty and Elmley Brooks. The Salwarpe rises in a valley in the western side of Beacon Hill, Upper Lickey Hills, in the grounds of the house called " Heanor." It flows through the Chadwick Pools, by way of Upper Catshill, to the west, and then round to the south of Bromsgrove (where it is joined by the Spadesbourne Brook), by Wychbold, and into the Droitwich Junction Canal east of Droitwich (see Droitwich Junction Canal, p. 9).

' Hartlebury Brook.'

River Stour.—The Worcestershire Stour has numerous head-streamlets issuing from the base of the Enville Beds, from which the water is thrown out by the subjacent Keele Beds, in and in the vicinity of Uffmoor Wood on the northern slope of the Clent Hills ; but popular opinion appears to favour St. Kenelm's Well as the actual source. Thence the growing river flows through Halesowen (in a valley in the sides of which Halesowen Sandstones crop out), and Cradley, to Stourbridge, where it leaves the Coal Measures ; its further course along to the Severn at Stourport lies over the permeable Bunter Sandstones and Pebble Beds. Above Kidderminster the area of its basin is 78,080 acres ; the minimum rainfall 19.42 in., and the mean, 25.95 in. Prof. W. S. Boulton states that at Stewponey Lock (west of Stourbridge and in Staffordshire) it has a minimum volume of 6,000,000 gallons ; near Kidderminster of 8,250,000 gallons ; and at its junction with the Severn probably 10,000,000 gallons per day.[1] In the neighbourhood of Kidderminster the Stour receives the waters of numerous tributaries, which have been " stanked " (ponded) back at various places mainly to supply power to mills, the majority of which are now defunct. The upper reaches of the Stour have been under examination by the Medical Officer of Health for Staffordshire, who reported that certain reaches of the river were in an unsatisfactory state, as measured by the content of dissolved oxygen. The river through Worcestershire has been examined by the Kidderminster R.D.C., and analyses on their behalf have been made by Mr. Duncan. The evidence points to considerable local pollution towards the confluence of the river with the River Severn.[2]

[1] *Engineer*, 1920, p. 647.

[2] River Pollution and Fisheries. *Ministry Agric. and Fisheries.* Third report, 1926, p. 10.

THE TRENT SYSTEM

Only a comparatively small area of Worcestershire lies in the Trent basin. The divide between the Trent and Severn systems runs from Dudley along the Rowley Hills, by way of Blackheath, Woodgate, and Frankley Green to Gannow Green, thence between Rednal and Longbridge to Grovely House, by way of Westhill—which is pierced by the Worcester and Birmingham Canal tunnel—Forhill, Weathercock Hill, Birch Acre to Branson's Cross.

Tributaries of the Teme drain Oldbury ; the Rea and tributaries the ground declining to Cannon Hill Park, Birmingham ; and the Cole and tributaries the remaining tract to the east.

The Rea rises at Gannow Green, near Rubery, and flows past Longbridge through Wychall and Lifford reservoirs, Ten Acres and Cannon Hill Park. It is joined at Ten Acres by The Bourn ; at Cannon Hill Park by Bourn Brook, which drains the tract between Bartley Green and Harborne, and flows through the Harborne reservoir. Just before the Bourn Brook joins the Rea it receives the waters of the Chad Brook, which rises near Beech Lanes, goes under the Lordswood Road, down the valley that is traversed by the Harborne Road, and through the pool in Edgbaston Park.

THE THAMES SYSTEM

Portions of Broadway and Blockley parishes, of Cutsdean parish in the North Cotteswolds, Evenlode in the Vale of Moreton, and Daylesford—partly in the Vale and partly on the slopes of a spur of the Oxfordshire Downs—are in the Thames basin. A small part of Cutsdean parish is drained by the Windrush : the large part and the portions of Broadway and Blockley parishes by a tributary of the Windrush—the Dikler. Little water appears at the surface, the Inferior Oolite rocks as a whole being too permeable. A spring thrown out by a clay bed in the Oolite Series appears at " Far " Upton Wold ; but the Dikler below this point down to Waterhead Barn, is a true bourne—water only runs continuously down the valley in wet periods. Evenlode and Daylesford are drained by the River Evenlode.

CANALS

Worcester and Birmingham Canal.—This canal, the property of the Sharpness New Docks and Gloucester and Birmingham Navigation Company, is 30 miles long and has 58 locks, 30 of which constitute the famous " flight " of Tardebigge. It commences by a junction with the main line of the Birmingham Canal Navigation at Worcester Bar, Birmingham, and proceeds by way of Selly Oak, Bournville, Lifford, King's Norton, Hopwood, Alvechurch, Tardebigge, Stoke Prior, Hanbury Wharf, Hadzor, Oddingley, Tibberton and Hindlip to Diglis, Worcester, where it joins the Severn. An improvement scheme was discussed by the Royal Commission on Canals and Waterways, from whose Report the details given below have been extracted.

The main supplies to the Birmingham-Worcester Canal are by means of the Wychall, Upper Bittell, Lower Bittell, Cofton, and Tardebigge reservoirs ; the Westhill, Hopwood, Cobley and Hen Brooks.

Name of Feeder	Area of Catchment Basin.	Rainfall		Maximum quantity available for July in a year of minimum rainfall	Maximum quantity available for July in a year of mean rainfall
		Min.	Mean		
	Acres	In.	In.	Cub. ft.	Cub. ft.
Westhill Brook ...	499	21.13	28.82	344,000	851,000
Hopwood ,, ...	134	21.30	28.82	92,000	229,000
Cobley ,, ...	390	21.30	28.82	269,000	665,000
Hen ,,	1,286	18.90	25.57	794,000	1.961,000

Reservoirs of the Worcester and Birmingham Canal.

Name of Reservoir	Capacity	Top water level		Catchment area, excluding water surface	Rainfall		Maximum available July in a year of minimum r'nf'll	Maximum available July in a year of mean r'nf'l
					Min.	Mean		
	Cub. ft.[5]	Ft. above O.D.	Acres	Acres	In.	In.	Cub.ft.[5]	Cub.ft.[5]
Wychall ...	4,600[3]	470.46	16	3,612	21.30	28.82	5,000	7,200
Cofton ...	3,500[3]	596.89	12	1,037	21.30	28.82	} 4,600	9,000
Upper Bittell	27,878.4	505.56	96	761[1]	21.30	28.82		
Lower Bittell	15,000[3]	453.39	36	1,186	21.30	28.82	6,833[4]	4,237
Tardebigge[2]	4,788	405.55	17	—	—	—	—	—

Pumping Station	Description of Pumps	Capacity of Pumps per 24 hours	Source from which water is raised	Position at which it is delivered
		Cub. ft.		
Upper Bittell (1837)	Cornish Beam Engine	901,152	Lower Bittell Reservoir and Canal Arm	Into Upper Bittell Reservoir which feeds the Summit
Tardebigge (1837)	Ditto.	321,753	Tardebigge Reservoir	Summit

From all the streams and reservoirs mentioned above, except Upper Bittell, supplies of water have to be made available for the use of millers on the Rivers Rea and Arrow, while Lifford reservoir (9 acres) and Harborne (19 acres) are entirely reserved for their use, and have no connection with the canal supply whatever.

Droitwich Junction Canal.—1 mile 20 chains long. Forms a link between the Worcester and Birmingham Canal at Hanbury Wharf (154.73 ft. above O.D.) and the Droitwich Canal in Droitwich.

Feeder	Area of catchment Basin	Rainfall		Maximum quantity available for July in a year of minimum rainfall	Maximum quantity available for July in a year of mean rainfall
		Min.	Mean		
	Acres	In.	In.	Cub. ft.	Cub. ft.
River Salwarpe	18,700	19.01	26.24	11,540,000	29,189,000

Droitwich Canal.—5 miles, 76 chains long : joins the Droitwich Junction Canal in Droitwich with the River Severn (Severn Navigation) at Hawford (39.6 ft. above O.D.) proceeding *via* Salwarpe and Ladywood. Now practically derelict.

Birmingham Canal Navigation.—Portions of the canals of the Birmingham Navigation come into the Worcestershire parts of the South Staffordshire

[1] Including portions of the River Arrow, 384 acres, led by culvert into the reservoir.
[2] No catchment. Fed by overflow from Summit reach, supply returned to summit by pumping.
[3] Estimated capacities.
[4] By pumping.
[5] 000's omitted.

Coalfield. No water derived from Worcestershire, however, is put into the canals: the several pumping stations [1] and reservoirs [2] simply effect the transfer of water from one part of a canal to another and afford temporary storage of surplus.

At one time certain streams ran into the canals; but most of these have been lost to the canals owing to diversion by subsidence of the ground, due to mining operations. In places, canals which were at ground level are now on embankments: their statutory level has only been maintained by the addition of banks.[3]

The Dudley Canal runs from Windmill End, *via* Rowley Regis, through the Lapal Tunnel (2 miles 1 fur. 248 chs.), to California, and into the Worcester and Birmingham Canal at Selly Oak. At Waterfall Lane, Staffordshire, water from the Pumping Station of the Old Hill Mines Drainage Scheme (1922) is run into it (see p. 21).

Staffordshire and Worcestershire Canal.—A small portion of this canal is in Worcestershire. It begins at a junction with the Severn at Stourport and runs through Kidderminster into Staffordshire.

The Sleepy Mill Feeder, which enters the canal between Cookley and Whittington Locks, drains an area of 544 acres, on which the minimum rainfall is 19.42 in. and the mean 25.95 in.

Rainfall

By B. Brotherton, F.R.G.S.

As seen from Elbury Hill, 323 ft., near Worcester, the county consists of an undulating plain, drained by the River Severn and its tributaries, whose average height does not exceed 100 ft. above sea level. In the west the Malvern ridge rises abruptly from the plain to a height of 1,395 ft. The triangular portion of the county bounded by Martley, Bewdley, and Tenbury also contains land of considerable elevation, notably Woodbury Hill, 904 ft., and Abberley Hill. The Clent, 1,036 ft., and Lickey Hills, stretching north-west to south-east, are on the border of an elevated area in the north-east of the county. Bredon Hill, 977.6 ft. in the south-east, is an outlier of the Cotteswolds.

This configuration influences the rainfall of Worcestershire in a marked degree, for the distribution of rainfall over a long period bears a close relationship to the height and form of the land. This is also true to a very great extent for each individual year, but individual months do not show by any means so close a relationship, very heavy rain sometimes occurring in regions which on the average are comparatively dry, and very light rain sometimes occurring in regions which on the average are wet. This deviation is mainly due to thunderstorms or cyclonic rains, which may affect any part of the county and bring a fall of 4 inches or more in the case of thunderstorms, or even as much as 8 inches in the case of cyclonic rains, in a period of 24 hours, without any regard whatever to the configuration of the ground. The fact that such heavy rains are rare and do not often occur twice in one year in the same place, enables the control of rainfall by the orographic features to assert itself in the total of the year, and to be absolutely predominant in the average of many years.

[1] The Lapal Engine has been disused for many years.

[2] Gads Green Reservoir was rendered useless by mining operations causing subsidence, and had to be abandoned.

[3] Royal Commission on Canals and Waterways. Reports, vol. II (1908), p. 166.

In " British Rainfall " for 1921 Worcestershire is given as one of a group of six West Midland Counties, with an area of 751 square miles, and the number of observers 59. The Table of Rainfall Statistics (p. 12) has been largely compiled from the records of these observers to the end of the year 1922. In some cases it has been possible to give the average values for all climatological elements for official meteorological work. The others show the average for the number of years the record has been kept. It is well to note that short periods very often show too high or too low an average. This is well shown in the following table :—

Station	Years	1st Average, Ins.	Years	2nd Average, Ins.	Standard[1] Average, Ins.
Dudley	5	28.26	17	27.00	25.14
Knightwick ...	4	29.30	12	27.51	26.58
Redmarley ...	3	31.68	11	27.24	26.33
Evesham ...	6	27.01	14	25.05	24.10

When the averages in the table on p. 12 are examined, it will be seen that Worcestershire does not present great variations in its rainfall. It is, however, clear that a dry belt whose average lies between 24 and 25 inches exists between the two high regions of the west and north-east. The western wetter region has averages varying between 27 inches and 29 inches, while Alvechurch in the north-eastern area has an average of 30.18 inches. Upton Wold, Blockley, in the detached portion and on elevated Cotteswold ground in the south-east, has the comparatively high average of 31.69 inches. The extreme yearly limits lie between 45.56 inches at Blockley in 1912, and 14.63 inches at Bewdley in 1921. The wettest month seems to have been August, 1912, when 9.50 inches was recorded at Malvern, and the driest month, April, 1912, when .00 inches was recorded at Holt Lock. The rainfall for 1921 was probably the smallest ever recorded. Other dry years were 1854, 1864, 1870, 1887, 1896, 1898, 1901. The three wettest months are October, August and December, and the three driest are February, September and April.

The value of one inch of rain over the 751 square miles of Worcestershire is 48½ million tons or 10,874 million gallons. Multiply these figures by 25 as an average annual rainfall for the county and it will be seen what an astonishing amount falls in a year. When excessive quantities fall in short periods floods of the Severn and its tributaries occur, as in the following years :—1484, 1672, 1795, 1809, 1852, 1886, 1910, 1914, 1915, 1923.

[1] In order to standardize a record, the process is as follows : Add up the percentage values for the period covered and divide by the number of years. This gives the mean percentage for the period in question which may be called x. Multiply the arithmetical average rainfall at the station by $\frac{100}{x}$. This gives the desired standardized average, equivalent to the average for the whole 35 years.

Rainfall Statistics for Worcestershire to December, 1922.

Station	Height above sea-level in feet	Observer	Yearly average, Inches	No. of yrs.	Maximum	Year	Minimum	Year	Maximum	Month	Minimum	Month
					Inches	Date	Inches	Date	Inches	Date	Inches	Date
Worcester	180	B. Brotherton, Esq. G. B. Wetherall, Esq.	24.24	35	33.60	1912	16.47	1921	7.03	Aug., 1912	.06	Ap., 1912
Droitwich	98	H. Hulse, Esq., C.E.	26.83	13	37.09	1912	17.50	1921	7.68	Aug., 1912	.04	Ap., 1912
Malvern	520	A. Mander, Esq.	29.04	34	43.00	1912	18.81	1921	9.50	Aug., 1912	.10	Feb.,1891 } Feb.,1895 }
Upton-on-Severn ...	46	I. Selwyn Cowley,Esq.	25.96	35	37.70	1912	17.82	1921	7.85	Aug., 1912	.10	Ap., 1912
Redmarley ...	280	Miss F. L. Newbury	27.24	11	38.27	1912	16.09	1921	7.46	Aug., 1912	.11	Ap., 1912
Evesham	128	Messrs. Ross Bros., Ltd.	25.05	14	36.90	1912	14.76	1921	6.88	Aug., 1912	.11	Jly., 1911 } Ap., 1912 }
Upton Wold, Blockley	800	E. W. Arkell, Esq.	31.69	25	45.56	1912	17.97	1921	—	—	—	—
Alvechurch ...	580	D. B. Grubb, Esq.	30.18	47	41.95	1912	19.76	1921	8.24	Aug., 1912	.03	Ap., 1912
Hewell Gardens, Redditch... ...	469	F. Molyneaux, Esq.	28.19	22	39.40	1912	18.92	1921	7.96	Aug., 1912	.05	Ap., 1912
Barnt Green ...	650	Miss M. Gibbins	26.36	17	34.59	1912	17.02	1921	7.04	July, 1915	.03	Ap., 1912
Dudley	591	F. H. Gibbons, Esq., C.E.	27.00	17	34.82	1912	15.30	1921	7.36	July, 1915	.00	May, 1921
Kidderminster ...	160	J. F. Cowderoy, Esq.	22.95	33	32.50	1912	15.87	1921	6.61	Sep., 1918	.03	Ap., 1912
Tenbury	313	F. Lowe, Esq.	27.17	22	37.62	1912	18.20	1921	7.36	Dec.,1911	.10	Ap., 1912
Bewdley	175	Miss K. M. Sturt	24.69	19	33.86	1912	14.63	1921	6.52	Sep., 1918	.07	Ap., 1912
Martley	220	Rev. J. F. Hastings	26.94	28	41.78	1912	18.22	1921	8.83	Aug., 1912	.10	Ap., 1912
Knightwick ...	300	H. Gordon Smith,Esq.	27.51	12	38.76	1912	17.12	1921	8.27	Aug., 1912	.13	Ap., 1912
Stourbridge ...	215	W. Fiddian, Esq.	27.28	23	36.46	1912	18.86	1921	7.39	Sep., 1918	.16	Ap., 1912
British Camp (Malvern Hills) ...	677	W. Osborne Thorp, Esq., C.E.	29.22	18	42.12	1912	16.72	1921	8.75	Aug., 1912	.11	Ap., 1912
Bevere Lock ...	52	E. J. Bradley, Esq.	24.48	35	36.48	1912	17.25	1921	6.86	Aug., 1912	.04	Feb., 1891
Holt Lock	55	Do.	25.26	35	37.56	1912	16.86	1921	7.47	Aug., 1912	.00	Ap., 1912
Lincomb Lock ...	62	Do.	25.57	35	35.82	1882	18.39	1921	7.82	Sep., 1918	.00	Ap., 1912
Upper Lode ...	41	Do.	25.22	35	—	—	—	—	—	—	—	—
Birmingham ...	525	A. J. Kelley, Esq.	26.04	35	35.98	1912	18.024	1921	6.509	Sep., 1918	.06	Feb., 1891
Bredon	120	J. Lambert, Esq.	23.82	5	27.24	1919	17.13	1921	5.42	Sep., 1918	.19	Feb., 1921
Shipston	241	W. L. Stanton, Esq.	25.84	14	34.26	1912	16.12	1921	6.19	Aug., 1912	.11	Ap., 1912
Shelsley Grange ...	350	A. G. Burney, Esq.	25.03	3	29.17	1922	16.88	1921	5.74	Feb., 1923	.23	Oct., 1922
Stockton on Teme...	200	Miss M. Wallace	27.63	35	40.50	1872	16.75	1921	7.00	July, 1875	.09	Ap., 1912
Bromsgrove ...	455	F. A. Jones, Esq.,C.E.	27.48	35	—	—	—	—	—	—	—	—
Pedmore	340	F. Grazebrook, Esq.	28.51	44	—	—	—	—	—	—	—	—

II.—GEOLOGICAL STRUCTURE

A.—Tabular View of Formations in Worcestershire.

In this table the main geological divisions and subdivisions of the rocks occurring within the county are set out in descending sequence. Further subdivision of some formations will be found in the succeeding pages.

			Approximate thickness in feet
NEOZOIC			
SUPERFICIAL DEPOSITS			
Recent to Pleistocene :—			
Recent		Alluvium	up to say 20
Recent and Pleistocene		River Terraces of sand and gravel	20, or more
Pleistocene (Glacial)		Boulder clay ... Quartzose sand and gravel	50
SOLID FORMATIONS			
Jurassic :—			
Great Oolite & Fullers' Earth Inferior Oolite		Limestones and thin clay beds	up to 100
		Oolitic limestones, clay, sand and sandy limestone	up to 205
Lias	Upper	Cotteswold Sands ...	0 to 25
		Clay with occasional limestone-nodules and thin bands of limestone at the base ...	up to 270
	Middle	Marlstone	up to ?58
		Sandy Beds.—Sandy clays and shales ...	up to ?222
	Lower	Clay almost entirely in the upper part, and limestones and clays or shales in alternating bands in the lower part	up to 950
Triassic :—			
Rhaetic		Marls and black shales with occasional thin limestone and sandstone bands	30 to 40

Keuper	Keuper Marl	Tea-green Marls ...	up to 35
		Upper Marls. Red marls with spots and bands of bluish-green colour	85 to 180
		Arden Sandstone (Upper Keuper Sandstone)	0 to 40
		Lower Marls. Similar to Upper Marls, with gypsum and—in the Droitwich-Stoke Prior area—salt	up to ?1,500
	Lower Keuper Sandstone	Sandstones (Waterstones), Sandstones (Building Stone), Sandstones, conglomerates, and breccias...	up to 400
Bunter	Upper	Upper Mottled Sandstone	160 to 275
	Middle	Pebble Beds	up to 384
	Lower	Lower Mottled Sandstone	up to 275

Unconformity

PALAEOZOIC

CARBONIFEROUS :—

Coal Measures. (For details see pp. 19, 23).

Unconformity

DEVONIAN (OLD RED SANDSTONE) [1] :—

'Upper' (Absent from Worcestershire).

'Lower'	Dittonian	Marls with cornstones and sandstones—the *Cephalaspis* - Sandstone at the base ...	800
	Downtonian	Red marls with sandstones at very wide intervals, and thin (Birch Hill) limestones	1,610
		Temeside Shales ...	350
		Downton Castle Sandstone	80 to 100

SILURIAN :—

Ludlow	Upper	Sandy shales and thin limestones	100 to 200
	Aymestry Limestone	Concretionary limestone	40 to 250
	Lower	Sandy shales ...	700 to 750
Wenlock	Wenlock Limestone	Nodular limestone and shale	280 to 400
	Wenlock Shales	Sandy shales ...	600 to 850
	Woolhope Limestone	Impure limestone ...	10 to 250

[1] See p. 17, footnote [1].

Llandovery	Tarannon Shales	Purple shales ...	100 to 350
	May Hill Sandstone	Grey and purple sandstones with calcareous bands ...	920 to 1,400

Unconformity

CAMBRIAN :—			
Tremadoc and Upper	Bronsil	or Grey Shales ...	about 1,000
	White-leaved Oak or Black Shales ...		about 1,000
Middle and Lower	Hollybush Sandstone	Grey and brown sandstones	about 600
	Lickey and Malvern Quartzites	Lickey Quartzite ...	800
		Malvern Quartzite ...	several hundred ft.

Unconformity

ARCHAEAN :		
Uriconian type	Various volcanic rocks	
Malvernian type	Red binary granites, gneisses and schists	

Of various ages. Igneous rocks.—Basalts, dolerites, diorites, etc.

B.—General Description, with special reference to Water Supply

ARCHAEAN

Archaean rocks appear at the surface in Worcestershire in the prominent, serrated, north-and-south ridge of the Malvern Hills, and in a little tract in the grounds of Barnt Green House near Barnt Green Station.

The Archaean rocks of the Malvern Hills project from betwixt two important faults (Fig. 2). By the fault along the west side of the hills Palaeozoic rocks have been let down and locally inverted : that along the east side of the hills brings down Mesozoic strata. The Archaean rocks are principally binary granites, gneisses and schists, with a concealed core of basaltic rock (epidiorite, proved in the Colwall railway tunnel) and belong to the Malvernian group ; flanking them, and forming eastern spurs of the Herefordshire Beacon, are volcanic rocks of the Uriconian group.

Though the extremely narrow and steep-sided ridge offers but a restricted catchment area, in-sinking is assisted to some extent by the numerous fissures, large and small, by which the Malvernian rocks are rent. Part of the rainfall issues as springs from those fissures, and part runs off the surface ; in either case, owing to the insolubility of the constituent minerals of the Malvernian, the water is found to be practically as soft, or deficient in dissolved solids, as when it fell. This softness is the quality that has gained for Malvern Waters their fame in the medical world. As soon,

however, as the hill-waters transgress the boundary faults they become changed by the rocks over or through which they flow : thus, if they traverse the Silurian to the west they become very hard, whilst after flowing through the hill-débris that rests on Keuper Marl on the eastern side of the hills they are found in places to be chalybeate.

Practically all the springs of any size on the hills are in use, chiefly for public supplies ; of those in private hands, several are in connection with the mineral-water industry.

CAMBRIAN

Rocks belonging to this system occupy but small tracts at the surface : the most important is that of the Lower Lickey Hills, where the hard Lickey Quartzite gives rise to the prominent ridge which bears that name. This Quartzite, which is well exposed in ' The Gap ' at Rednal, originates but few springs : such as do occur on the ridge are insignificant and mostly the product of surface drainage. Beds equivalent to the Lickey Quartzite, succeeded by shales with associated igneous rocks, are present in the neighbourhood of the Valley of the White-leaved Oak, South Malverns, but only a small area of them comes in Worcestershire. The same remark applies to the succeeding grey shales—the Bronsil Shales—and they are of no interest from the present standpoint.

SILURIAN

The sequence of the constituent series of the Silurian System, their lithic characters and thicknesses are given on pp. 14, 15. The beds are known to occur (1) along a narrow tract flanking the west side of the Malvern Hills and running thence northwards to the Abberley Hills,[1] and (2) beneath part of the Worcestershire portion of the South Staffordshire Coalfield, locally, as at Lye, projecting through the Coal Measures. The permeable beds of the Silurian cannot be regarded as a potential source of useful supplies, owing to the limited extent of their outcrop. The Llandovery is the most productive, and small quantities of hard water are also met with in the limestones, but such springs as are encountered on the shales are mostly the products of surface-drainage.

OLD RED SANDSTONE

The Old Red Sandstone floors the Tenbury Rural District ; occurs at the surface and immediately between the outcrops of Coal Measures in the Martley Rural District to the west of the Silurian ridge of which Ankerdine and Abberley Hills are well-known prominences ; is present at the surface in and immediately underlies the Coal Measures of the Rock Rural District ; immediately underlies the Coal Measures of Bewdley Borough and of the parishes of Dowles and Upper Arley in the Kidderminster Rural District ; occurs at the

[1] The geographical distribution of the Silurian of this tract is shown on maps accompanying Prof. T. T. Groom's papers in *Quart. Journ. Geol. Soc.*, vol. lv, 1899, pl. XIII, and vol. lvi, 1900, pl. VIII.

surface in the neighbourhood of Trimpley in the parish of Kidderminster Foreign; and immediately underlies the Coal Measures of the greater part of the Worcestershire portion of the South Staffordshire Coalfield.

Sequence of Old Red Sandstone Beds [1]

		Approximate thickness in feet	
Dittonian	Cornstones and green grits and marls	150	
	Red sandstones and marls	150	
	Hall Barn corn stonesand sandstones...	130	
	Red marls and thin sandstones... ...	350	
	Cephalaspis-Sandstone. Very variable in character and thickness ... say	20	
	Total thickness (as at Brown Clee) ...	800	800
Downtonian	Purple sandstones and red clays ...	130	
	Eastham Sandstone, red marls and sandstones	150	
	Downtonian or Birch Hill Limestone (corniferous): 4 to 30 ft. ... say	20	
	Red marls	300	
	Trimpley Fish Zone with marls... ...	100	
	Red marls	500	
	Holdgate Sandstone, 10 to 15 ft., say	10	
	Red marls...	440	
	*Ledbury Fish Beds, 10 ft., and at Ledbury 25 ft.	10	
	*Temeside Shales	360	
	*Downton Castle Sandstone	80	
		2,100	2,100
			2,900

The Old Red Sandstone was considerably flexed and denuded before the Coal Measures were accumulated in depressions in its surface (see Fig. 1). So far as the north-eastern portion of the county is concerned it is easy to see from the course of the outcrop of Mr. King's Birch Hill Limestone—the cornstone shown on the geological maps—that the principal axes of these flexures were the Clee-Hills–Rock and Kimbolton–Bromyard synclines, with an intervening Teme Valley anticline. The flexed strata were subjected to denudation and all the 'Upper' Old Red Sandstone was removed from Worcestershire. The Dittonian is well developed at the Clee Hills

[1] This description of the lithic characters of the rocks has been communicated by W. Wickham King. The current Survey classification of these rocks is as follows: the Downtonian comprises strata from the top of the Ludlow Bone-bed (regarded as the highest member of the Ludlow Series) to the base of the *Cephalaspis–Pteraspis* fauna, and is included in the Silurian system (See 'The Country between Wolverhampton and Oakengates' (*Mem. Geol. Surv.*), 1928, p. 19); the overlying beds are included in the Lower Old Red Sandstone, but the term Dittonian is not used.

* As in South Staffordshire (See T. H. Whitehead in 'The Geology of the Southern Part of the South Staffordshire Coalfield' (*Mem. Geol. Surv.*), 1927, p. 9 *et seqq.*, and papers there uoted).

in Shropshire, where it is 600 ft. thick: the higher beds of the Downtonian occur in the synclinal areas referred to above, while lower beds are exposed in the Teme and tributary valleys.

The Birch Hill Limestone—or "The Limestone" as it is called locally—is of importance from a water-supply standpoint. This is because the rocks above it are principally porous sandstones whilst those below it are mostly impermeable marls. Water finds its way through the sandstones and limestone and issues in the form of many springs at its base, being thrown out by the subjacent marls. These springs are extensively used for the supply of mansions, farms and cottages. The water is hard, and locally the springs make considerable deposits of travertine.

Excluding the water-bearing Holdgate and Downton-Castle Sandstones, the Downtonian beds below the Birch Hill Limestone are principally marl, and little water sinks in: the bulk of it runs off—as in the Teme valley at Eastham—in numerous deeply-cut water-courses.

An interesting point about such water as is met with in the beds from the Holdgate Sandstone downwards is that it is often highly saline. Such waters occur at Saltwells, near Dudley, and are met with in many pits in the South Staffordshire Coalfield; they rise in boreholes started in the Coal Measures in the valley of the Dowles Brook in Wyre Forest, and are encountered also at Tenbury Wells, and at Salty Brook, near Lye.

CARBONIFEROUS

Small patches of Coal Measures occur at Berrow and Woodbury Hills and at Martley [1]: but the important areas are in the Worcestershire portions of the Forest of Wyre and South Staffordshire Coalfields. Lower Coal Measures are absent from Worcestershire; so are the Millstone Grit, Carboniferous Limestone, Lower Limestone Shales, and 'Upper' Old Red Sandstone. In the Worcestershire portions of the Forest of Wyre Coalfield the Coal Measures rest probably everywhere on the Lower or Downtonian division of the 'Lower' Old Red; in the Worcestershire portion of the South Staffordshire Coalfield on Downtonian and Silurian. In both coalfields where the Downtonian forms the pre-Coal Measure floor, salt water is encountered in boreholes and shafts that reach it.

Following the classification proposed by T. H. Whitehead,[2] the well-known Trappoid Breccia and associated beds and their equivalents and the subjacent Calcareous Conglomerate Group (the Upper and Middle Permian respectively of Wickham King[3]) are regarded provisionally as 'Upper Coal Measures.' These beds, together

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[1] Groom, T. T., *loc. cit.*, vol. lvi, 1900, pp. 163 *et seqq.*

[2] 'Summary of Progress' for 1921 (*Mem. Geol. Surv.*), 1922, p. 173.

[3] 'Permian Conglomerates of the Lower Severn Basin,' *Quart. Journ. Geol. Soc.*, vol. lv.; 1899, p. 97. In Hull's classification, both trappoid breccias and calcareous conglomerates are included in the Middle Series of the Lower Permian (Salopian type), that is, of the only Permian rocks found in the south and central Midlands ('Triassic and Permian Rocks of the Midland Counties of England' (*Mem. Geol. Surv.*), 1869, chap. II, especially pp. 10, 11, 13).

with the Keele Beds, are the strata that were placed by Jukes [1] in the Permian System, and as such are represented on the one-inch Geological Survey Maps (Old Series). The Trappoid Breccia is excellently developed in the Clent Hills, is much reduced in thickness at other localities, is locally represented merely by thin breccia beds associated with sandstones and marls,[2] and overlies a Calcareous Conglomerate Group—the whole forming one group that has been named the Enville Beds.[3] These Enville Beds, and particularly the Trappoid Breccia, are absorptive of water, which is held up in them or thrown out from them by the marls of the subjacent Keele Beds. The comparatively limited geographical extent of the Enville Beds in this county makes them an unsafe source of supply except for small undertakings.

The Trappoid Breccia and accompanying beds occur in isolated masses associated with the Silurian of the narrow belt extending from the Malvern to the Abberley Hills; at Stagbury Hill (about a mile west of Stourport); Church Hill, Bayton; Warshill (some two miles west of Kidderminster); in the Clent Hills (where it attains its maximum thickness estimated at 450 ft.); between the Clent and Lower Lickey Hills; at Ley Hill, Northfield; and in the Warley area, where it is largely represented by sandstones and marls. At all these localities it contains water. Bayton village has a supply from Church Hill; numerous springs issue from the south-western slopes of the Clent Hills; the source of the River Arrow is a spring issuing from Beacon Hill in the Upper Lickeys; while Ley Hill, Northfield, has water raised by a windpump from a well in this rock. Certain boreholes in the Stourbridge district reach the Breccia, and one at Burcot, belonging to the East Worcestershire Waterworks Company, goes far into it (p. 137).

The two coalfields are now considered separately.

South Staffordshire Coalfield [4].

In the Worcestershire portion of this coalfield) the sequence is as follows:—

			Approximate thickness in feet
? Upper Coal Measures	Enville Beds (=Upper and Middle Permian of King)	Breccia or Clent Group[5]: Marls with included breccias which in the Clent Hills have an estimated thickness of 450 ft. and are known as the 'Trappoid Breccia'	600 to 650
		Calcareous Conglomerate or Romsley Group[5]: Calcareous sandstones, locally conglomeratic, interbedded with marls and sandstones ...	200 to 400

[1] 'The South Staffordshire Coal-Field' (*Mem. Geol. Surv.*), 2nd ed., 1859, chap. iv.
[2] King, W. Wickham, *Quart. Journ. Geol. Soc.*, vol. lv, 1899, pp. 111–118.
[3] Arber, E. A. N., *Trans. Inst. Min. Eng.*, vol. lii, 1916, p. 38; and T. H. Whitehead, *op. cit.*
[4] See T. H. Whitehead and T. Eastwood, 'The Geology of the Southern Part of the South Staffordshire Coalfield' (*Mem. Geol. Surv.*), 1927.
[5] The terms Clent Group and Romsley Group were proposed by E. A. Newell Arber (*op. cit.* pp. 38, 39).

			Approximate thickness in feet
Upper Coal Measures	Keele Beds (=Lower Permian of King[1])	Impervious marls, with local sandstone beds, of variable water-containing capacity, cornstones and *Spirorbis*-Limestones	500 to 900
	Halesowen Beds [2] (Two-thirds to some extent water-bearing)	Clays, grey, olive, blue and red; with thin coals and lenticular sandstones (including the 'Third Sandstone' in the Hagley and Wollescote areas)	150 to 200
		Clays, grey, with a coal seam and a *Spirorbis*-limestone ...	20 to 30
		Sandstones, grey and yellow ('Second Sandstone') ...	20 to 100
		Halesowen Coal Group : clays, grey, with a coal seam and, in places, a *Spirorbis*-limestone	10 to 50
		Basal Sandstone : grey and yellow, with pebbly sandstones locally at base ...	about 100
	Etruria (Old Hill or Oldbury) Marls [2]	Impervious red and mottled clays and marls with interstratified and locally water-containing green grits and ashy conglomerates or Espley Rock	150 to 800
Middle Coal Measures	Productive Measures	Mostly impervious grey clays and shales but locally containing water-bearing rocks such as the New Mine Sandstone and Thick Coal Rock...	250 to 500

Unconformity

Irregular platform of Downtonian ('Lower' Old Red) and Silurian ranging from Upper Ludlow to Llandovery,[3] folded into ridges and hollows.

The greater part of the populous area of the Worcestershire portion of the coalfield is supplied by the South Staffordshire Waterworks (see p. 141) : the remainder mostly by the Stourbridge and District Water Board (p. 141). There are wells in use on the margin of the field and even in areas served by the Company and Board, but they are gradually being reduced in number—rarely on account of the lack of water, but in some cases owing to the change from privy to water closets, and in others to local contamination having necessitated the Company's water being laid on.

The average rainfall on the southern part of the South Staffordshire Coalfield is 30 inches per annum. Since 1 inch of rainfall is equal to about 22,600 gallons, or 101 tons per acre, the average rainfall amounts to about 3,030 tons per acre per annum or 1,860 gallons per acre per day.

Except for sandstone between the impervious Keele Beds and Old Hill or Oldbury Marls and, below the latter, the New Mine Sandstone and Thick Coal Rock (referred to in the above table), the Coal Measures of the Worcestershire portion of the South Staffordshire Coalfield may be described as non-waterbearing.

[1] Lower Series of Lower (Salopian type) Permian of Hull, *op. cit.*, p. 13.

[2] The Halesowen Beds and Etruria (Old Hill) Marls were placed by E. A. Newell Arber (*op. cit.* p. 36) in the Transition Coal Measures of R. Kidston (*Proc. Roy. Phys. Soc. Edin.*, vol. xii, 1893–4, p. 183).

[3] See W. Wickham King, *Trans. Inst. Min. Eng.*, vol. lxi, pt. 5, 1921, pp. 151–168.

Mine-water in the South Staffordshire Coalfield.—Before coal was worked the bulk of the rainfall ran off the surface into brooks and rivers; but the methods of obtaining the coal in the early days of the industry, and, speaking generally, the lack of co-operation in dealing with mine water, have caused this southern portion of the coalfield—in the words of a report of a recent Inquiry—" to resemble nothing so much as a water-logged rabbit warren." [1]

" Up to the end of the 18th century there was comparatively little trouble with water. The rainfall was carried out of the area by the rivers, the percolation was not excessive, and any water that did enter the mines was dealt with by individual coal owners or occupiers. But as time went on the surface gradually became more broken and depressed, with the result that the streams were so damaged as to be unable to fulfil their normal functions. Then commenced the era of water difficulties in South Staffordshire. The surface water, unable to flow directly to the rivers, filled up the continually forming depressions, and shortly made its way bodily into the mines, passing to the dip and threatening the deeper workings." [2]

Prof. E. Hull stated in 1861 that " It is hoped that the Colliery Proprietors may be induced to combine, to unwater the large tracts now flooded near Dudley; as it is only by such united action that this desirable end can be accomplished." [3] But, as the Report of 1920 (p. 13) says, " This hope was not realized, and Mr. Howl stated that in 1865 statistics compiled on behalf of the British Association for the Advancement of Science showed that 50,000,000 gallons of water per 24 hours were being raised from the mines. This was proved to be far in excess of the rainfall in the district, and as all the rivers rise practically within the district, it was clearly demonstrated that to a considerable extent the same water was being pumped out of the mines over and over again."

In 1870 The Old Hill Mines Drainage Co., Ltd. was formed " for the purpose of the pumping dry and unwatering mines in the Old Hill District." This Company commenced the sinking of the two nine-foot shafts at the present Waterfall Lane Pumping Station and erecting a large pumping plant.

In 1872 conditions got worse, so that in 1873 the South Staffordshire Mines Drainage Act was passed by general consent. The Commissioners to be appointed under the Act were to take steps to prevent surface-drainage from entering the mines and to unwater mines. The Old Hill Mines Drainage Co. continued to function, but for the Commissioners, until 1878, when it was wound up and the works in hand completed by the Mines Drainage Commissioners (Old Hill District).

In an award dated 3rd July, 1874, made by Arbitrators appointed under the 1873 Act, the coalfield south of the Great Bentley Fault was divided into five districts:—

1.	Bilston area	4·47 sq. miles or	2,861 acres
2.	Tipton area	33·35 ,, ,, ,,	21,344 ,,
3.	Oldbury area...	13.88 ,, ,, ,,	8,883 ,,
4.	Kingswinford area	12.32 ,, ,, ,,	7,884 ,,
5.	Old Hill { Northern Sub-District / Southern ,, }	16.77 ,, ,, ,,	10,732 ,,

It was supposed that these areas were divided from each other by natural or artificial barriers and that no area was in danger of becoming flooded by water passing to it through any other area: the Oldbury area is separated from the Old Hill area by the Russell's Hall Fault (downthrow to south-west of from 40 to 150 yds.); the latter from the Kingswinford area by the Netherton Anticlinal. " Pounds "—that is, areas of mines in which the

[1] ' Report of the Committee appointed to inquire into the Drainage of the Mines in the South Staffordshire Coalfield ', 1920, p. 17.
[2] *Ibid.*, p. 13.
[3] ' Coalfields of Great Britain,' 1861, chap. x, p. 115 (footnote).

underground waters can be considered as self-contained, and impounded principally by faults—were located and delimited within each area. Thus in the Oldbury area is the Spon Lane Pound, separated by the Eastern Boundary Fault from the Cakemore Pound; in the Old Hill area, Waterfall Lane and Hawne Pounds, etc.; in the Kingswinford area, Lye and New Farm Pounds, etc. In 1919 it is estimated that at least 500,000 gallons a day were raised by local colliery owners in the Northern Sub-District of the Old Hill area; and 684,167 gallons per day in the Southern Sub-District or Hawne District.

In 1907 the Mines Drainage Commissioners decided to close the Waterfall Lane Pumping Station. Before doing so, however, they enquired of the Hawne Mines Drainage Association—a voluntary association devoted to keeping down the water in the Hawne District—as to whether they would make a contribution towards the upkeep of Waterfall Lane Pumping Station. The result of the enquiry being negative the Commissioners closed the Station in 1908. Water then filled the Waterfall Lane Pound and commenced to flow into the Hawne District: and in 1912, when Lord Dudley ceased to pump at Saltwells, some water came into the same district from that direction also. The Hawne Association in 1919 made advances for the acquisition of the closed Waterfall Lane Pumping Station, but it was found that the modernizing of the plant was beyond their means.

On March 15th, 1920, the President of the Board of Trade appointed a committee " to inquire into the present position in regard to Mines Drainage in the South Staffordshire Coalfield, and advise as to the steps to be taken to ensure the future security of the Mines and the proper industrial development of the District on an economic basis."

The Report (see footnote, p. 21) was published in 1920. It contains a wealth of interesting details, some of them embodied in the preceding remarks, but amongst others the recommendations made by the Committee were—in brief—these:

A comprehensive pumping scheme for the Tipton area to be abandoned;

Kingswinford area not to be taken into consideration at present for mines drainage;

Oldbury and Old Hill areas to be amalgamated; a new drainage Board to be appointed, which would acquire the Waterfall Lane Pumping Station from the South Staffordshire Mines Drainage Commissioners and provide new powerful pumping plant to raise water from an approximate depth of 870 ft. ex surface—that is, from below the floor of the Thick Coal.

The Old Hill Mines Drainage Scheme, 1922, is an outcome of the Report. The Waterfall Lane Pumping Station has had the pumping plant from the Deepfields Pumping Station in the Tipton District installed in it and the " come " of water—S. B. Priest informs me—will probably be about 500,000 gallons a day. The water is pumped into the Birmingham Level (453 ft. above O.D.) of the Birmingham Canal Navigations.

Consideration has been given to the possibility of using mine-water for various purposes. Large quantities are pumped into the canals. As a source for potable supplies it has been turned down—it is hard, and there would be grave risks of pollution, acids in the waters derived from chemical works at a distance having been detected. Samples from different mines had 32.15, 104.5 and 77.1 degrees of total hardness. (For analysis and bacteriological test, see pp. 179, 180; Nos. 639, 640).

As Prof. W. S. Boulton remarks:—" The water would, therefore, have to be artificially softened before it could be used for boiler-feed, but it would be quite suitable for cooling purposes." [1]

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[1] *Engineer*, 1920, p. 648.

Wyre Forest Coalfield.

The southern portion only of this coalfield occurs in Worcestershire—Upper Arley, Bewdley, Bayton, Mamble, Rock, Pensax, and Abberley are on it. The sequence of rocks is as follows :—

			Approximate thickness in feet
? Upper Coal Measures	Enville Beds	Occur in small tracts at Warshill and Stagbury Hill, and north of Upper Arley ...	
Upper Coal Measures	Keele Beds		
Transition Coal Measures (Sulphur Coal Series)		Clays and shales with several bands of ironstone and coal	400 +
		Sandstone	50 to 88
		Sulphur Coal Series. The principal coals are the Brock Hall Seam (Uppermost) and the Hard or Main Sulphur Coal (lowermost—in the Mamble region not far above the Old Red Sandstone) with a *Spirorbis*-Limestone in between ; the associated rocks are clays with occasional beds of ironstone and conglomerate	up to ? 121
		Unconformity. (" Symond Fault ")	
Middle Coal Measures (Sweet Coal Series)		At Shatterford :—	
		Upper Coal Series. Coals (7 seams, 6 in. to 2 ft. 8 in. thick) and measures ...	530
		Barren Measures	625
		Lower Coal Series. Coals (2 seams, 8 in. and 1ft. 1 in. thick) and measures	232 +
		Unconformity	
' Lower ' Old Red Sandstone			

The late E. A. Newell Arber said that in the Dowles Valley and Shatterford regions probably only Middle Coal Measures occur ; in the Mamble region only Transition Coal Measures.[1]

These Coal Measures rest in hollows in the ' Lower ' Old Red Sandstone and although it is uncertain at what depth they were penetrated it appears likely that the salt water encountered in the borings in the Dowles Valley at the Town Mill and Coventry Mill boreholes (pp. 96, 97) came from the Downtonian Beds of the ' Lower ' Old Red.

The dominant rocks throughout the coalfield are shales and clays : sandstones occur occasionally.

TRIAS

			Thickness Ft.
Rhaetic	Upper	Greenish-grey marls and shales with subordinate layers of limestone : about	20
	Lower	Black shales with subordinate layers of sandstone and limestone : about	20

[1] The latest account of the geology of this coalfield, with a geological sketch map, is contained in : R. Kidston, T. C. Cantrill, and E. E. L. Dixon, ' The Forest of Wyre and Titterstone Clee Hill Coalfields,' *Trans. Roy. Soc. Edin.*, vol. li, 1917, p. 999. See also E. A. N. Arber, ' On the Fossil Flora of the Wyre Forest, etc.' *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, 1914, pp. 363–445, which contains a detailed bibliography.

			Thickness Ft.
Keuper	Keuper Marl	Tea-green marls : up to 35 ft....	up to ? 1755
		Red and variegated marls : 85 to 180 ft.	
		Arden Sandstone (Upper Keuper Sandstone) : 0 to 40 ft. ...	
		Red and variegated marls with gypsum and locally rock-salt : up to ? 1,500 ft.... ...	
	Lower Keuper Sandstone	Sandstones, relatively thinly-laminated, micaceous, and marls (" Waterstones "), passing down into	up to 400
		Sandstones, reddish, brown or white (" Building - Stone Group ") passing down into	
		Sandstones, conglomerates and breccias, calcareous (Keuper Basement Beds)	
Bunter	Upper Mottled Sandstone	Sandstones, soft, bright red and variegated (without pebbles)	160 to 275
	Pebble Beds	Sandstones, harder, reddish-brown, passing into conglomerates, with a basal bed of calcareous breccia	up to 384
	Lower Mottled Sandstone	Sandstones, soft, bright red and variegated (without pebbles)	0 to 275

Rhaetic.—These beds crop out from between the Lower Lias and Keuper Marl along a narrow tract of country and are of little interest from the standpoint of water supply. Full particulars concerning the formation, as it is developed in Worcestershire, have been published elsewhere.[1]

Keuper Marl.—The Keuper Marl occupies considerable tracts in Worcestershire, principally in the neighbourhood of Birmingham, in Worcester City, the Urban Districts of Redditch and Malvern, and in the Rural Districts of Bromsgrove, Droitwich, Martley (south-eastern portion), Upton-on-Severn and Feckenham. Its presence can usually be readily detected by the red heavy ground to which it gives rise, but a considerable portion of its surface is covered by superficial deposits of sand and gravel. Its thickness is considerable : borings proved at the Gas Works, Malvern Link, 703 ft. ; Upton-on-Severn, 1,327 ft. ; Stoke Works, 800 ft. (without reaching the base) ; Elliott's Metal Works, Selly Oak, 624 ft. ; and Armscott, Tredington (7 miles S.S.E. of Stratford-on-Avon), perhaps 418 ft., or more. It constitutes a relatively impervious cover to the water-containing Triassic sandstones beneath, with the result that when it is pierced, water rises high up and sometimes overflows at the surface. Dug wells, which are anything up to 200 ft. in depth, appear

[1] Richardson, L., *Trans. Worcs. Nat. Club*, vol. iii (for 1899–1905), 1906, pp. 92–101.

to yield as a rule a sufficiency of water for limited requirements. The water derived from the marls comes through fissures in the rock : it is on the hard side, sometimes too hard to be satisfactory for ordinary domestic purposes, but outside the Droitwich–Stoke Prior area no occurrence of brine has been noticed. In three cases—a well at Lower Greenock Farm, Doddenham parish, another at Blackfield Farm, Cotheridge parish, and trial borings at Messrs. Cadbury, Ltd., Bournville, Birmingham—the presence of sulphuretted hydrogen gas has been noted. The main trouble, however, is the liability to contamination by the inflow of surface-drainage. Few wells are 'steined'[1]: shutting out the surface-water would greatly improve the quality of the well-waters. Contamination, from surface sources and, rarely, insufficiency of supply, have brought about the condemnation of many well supplies[2] and the extension of the mains of large undertakings over considerable tracts of Marl country.

In the Keuper Marl, at from 120 to 215 ft. below its upper limit, lies the Arden Sandstone (Upper Keuper Sandstone). It crops out in the parishes of Pendock, Eldersfield, Ripple, Norton-juxta-Kempsey, Spetchley, Tibberton, Inkberrow and Harvington, and yields useful supplies of water.

Lower Keuper Sandstone.—This is an important source of water. It occurs at the surface along a tract between the Clent and Abberley Hills ; around Bromsgrove ; and in small tracts around Coston Hackett ; between Longbridge and Northfield ; and south-west of Selly Oak, Birmingham. Windpumps at the Manor House, Northfield ; Bluntingdon ; Chaddesley Corbett ; The Grammar School, Hartlebury, etc., indicate that its water-resources are being made use of for private supplies ; while, here and there, rams indicate that springs issuing from it are also being utilized. Near Ombersley the southernmost extension of the main outcrop disappears beneath the Keuper Marl. The Elmley Brook, west of Westwood Park, floods quickly and water comes out at Turn Mill, but probably the River Severn prevents the appearance of noticeably fluctuating springs, varying according to the seasonal changes in level in the water-table, such as are often met with where a permeable formation dips down beneath an impermeable one.

The Keuper Sandstone probably underlies the newer solid rocks wherever they occur in the county. It has been reached beneath the Keuper Marl by boreholes at Malvern Link, Upton-on-Severn, Armscott, and at several works in the Birmingham district, but usually the water thus obtained is on the hard side, and in the case of works, there is the expense of pumping.

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[1] Or 'steyned,' i.e., lined with stone (or brick).

[2] Thus out of 253 samples taken from wells, mostly in the Marls, in the Upton-on-Severn Rural District, 178 were declared unfit for drinking purposes.

Bunter.—The Upper Mottled Sandstone, Pebble Beds, and Lower Mottled Sandstone are the most important source of water in the county. Some or all of these groups are tapped in the boreholes of the Birmingham Battery Company, Selly Oak ; of the Selly Oak and Longbridge Pumping Stations of the Birmingham Corporation's Waterworks (the former now abandoned as a source of supply) ; of the Burcot and Catshill Pumping Stations of the East Worcestershire Waterworks Company ; of the Stourbridge and District Water Board ; of the Kidderminster and Bewdley Waterworks ; and of a large number of works in Stourbridge and Kidderminster. Near Kidderminster, in particular, a number of residences have private boreholes or dug wells.

Where the Bunter crops out in the higher ground north-west, west, and south-west of Kidderminster, springs are few owing to the porous nature of the beds : but two small chalybeate springs are thrown out by a marly bed at the base of the Pebble Beds up Solcum Lane (near Blakeshall) and at Lea Bank on the Kidderminster—Bewdley road. Where the Pebble Beds crop out high up on the flanks of the hills north of Bromsgrove the occurrence of water in them is somewhat capricious. But in the low ground stretching from Stourbridge, past Kidderminster and Stourport, to Areley Kings, water is met very near the surface : in Kidderminster on Sundays, when pumping is not in progress, it overflows from some of the boreholes.

The water from the Bunter Beds is excellent in quality. Sometimes that from the Pebble Beds is on the hard side, owing—W. Wickham King suggests to me—to the presence of limestone pebbles ; cases have occurred where such waters have been tubed out with satisfactory results.

Wickham King informs me that in his experience the Upper Mottled Sandstone or Upper Bunter is fairly soft and except at Redstone Rock, near Stourport, rarely contains any pebbles but usually much loam, and so is good for wheat, etc. Also, that in the Pebble Beds or Middle Bunter coarse sandstones are encountered at the top before the first fine conglomerate is reached.

The Upper Mottled Sandstone at Stourbridge is from 250 to 275 ft. thick ; at Hackman's Gate, 200 ft. thick, and at Catshill 160 ft. thick. The Pebble Beds at Stourbridge (G.W.R. Goods Station borehole) are 384 ft. thick and at Clent rest directly on the Trappoid Breccia. The Lower Mottled Sandstone is 255 ft. thick at Highgate Common and 275 ft. thick at Enville.

JURASSIC

Lower Lias

The Lower Lias floors considerable parts of the south-eastern portion of the county, more especially in the Pershore and Evesham Rural Districts. It is essentially a clay formation, but numerous limestone-beds—which have been worked in many quarries—occur

in the lower third. It is notoriously a bad formation in which to seek water. Wells cutting the limestone beds tap limited supplies of very hard water, while those sunk in the succeeding clays sometimes fail to tap any at all, and where water is found, the bulk of it is more often than not surface or subsoil-water. Moreover, the water is hard, as a rule saline, and not infrequently impregnated with sulphuretted hydrogen [1]; leaving the wells uncovered often removes or diminishes this last defect. Away from its lower margin in the direction of the outcrop of the Middle Lias the Lower Lias increases in thickness—under Shipston-on-Stour it is probably from 300 to 400 ft. thick; at Mickleton in Gloucestershire a boring proved it to be 961 ft. thick; while a shaft at Bretforton proved 300 ft. of it without reaching its base.

Fortunately deposits of sand or gravel or the two combined occur locally on the surface of the Lower Lias. The presence of such deposits has been the determining factor in the selection of the original site for many a village or isolated buildings. Also it occasionally happens that a well cuts a vein or pocket of sand or gravel (derived from the Superficial Deposits) in the Lower Lias clay. Useful supplies—often of non-saline water—are thus occasionally obtained. Unfortunately, however, the wells in most cases are near dwellings, where, owing to the laxity of the occupants in matters of the disposal of sewage and other refuse, the sources of potable supplies have in many cases become contaminated, bringing condemnation of those supplies and pressure for new ones. As indicating how difficult it is to obtain potable supplies it may be mentioned that Dr. G. H. Fosbroke, the late County Medical Officer, says that between 1893 and 1909 sixty new houses in the Pershore Rural District had to be supplied with rain water for drinking purposes, adding that "rain-water is flat and insipid, but when uncontaminated by the receiving surface or air impurities, and when properly filtered and stored, is healthy." [2]

There is no doubt that in new and comprehensive schemes or in the extension of the mains of large existing waterworks lies the only ultimate solution of the difficulties of villages on the Lower Lias.

Not only is the Lower Lias a bad source of underground supplies, but it affects the waters that flow over its surface. E. B. Marten had samples of the waters of the Wyre (or Piddle) and Walcot Brooks analysed with a view to ascertaining their suitability for supplying Pershore town, but the analyst, E. W. T. Jones, reported that they were "dreadfully hard." [3] The same analyst determined the permanent hardness of the water of the Avon—which, together with its tributaries drains large tracts of Lower Lias country—as 17.58°, in addition to which there was contamination.

[1] Distillation of the Lower Lias shale has yielded a dark brown evil-smelling oily liquid, and an inflammable gas, e.g., at Broughton Hackett.

[2] Reports on the Water Supplies of . . . parishes . . . in the Pershore Rural District (published for Worcestershire County Council), 1910, p. 4.

[3] *Ibid.*, pp. 7, 55, 59.

Middle Lias

The Middle Lias, composed of sandy clays (Sandy Beds) succeeded by a rock-bed (Marlstone), succeeds the Lower Lias. It crops out in the northern portion of Oxenton Hill, the northern face of Bredon Hill, and in Broadway, Blockley, and Daylesford parishes. Useful springs issue locally from the base of the Sandy Beds ; and the Shipston-on-Stour supply is drawn from a strong one on the eastern outskirts of Ebrington village (Glos.). Teddington has a piped supply from a spring in a combe between Oxenton Hill and its higher neighbour The Knoll. At the foot of the steep slope in which the Sandy Beds crop out on the north side of Bredon Hill there have been numerous slips of Sandy Beds on to Lower Lias. The supplies for the Combertons are derived from springs issuing from such slipped masses ; Elmley Castle derived its supply from Middle Lias. The yield of these springs, even if coming from undisturbed Middle Lias, is, however, limited, for the beds dip southwards into the hill and do not reappear on the other side. At Broadway and Blockley the beds likewise dip into the hills ; but in these parishes valleys have been cut into the hills and in them some useful springs occur.

The water from the Middle Lias, particularly if it comes from the neighbourhood of the Marlstone, is occasionally noticeably chalybeate. There is a chalybeate spring in Shoals Lane, $1\frac{3}{4}$ miles E. by S. of Blockley Church.

Upper Lias

The Upper Lias succeeds the Middle Lias. At Bredon Hill it is clay (about 270 ft. thick) : in the North Cotteswolds a trace of Cotteswold Sands locally forms its top portion. The main interest which attaches to the Upper Lias clay is that it throws out the water that has worked through the superincumbent Oolite.

Inferior Oolite

The Inferior Oolite succeeds the Upper Lias (or in the North Cotteswolds a thin deposit of Cotteswold Sands), caps Bredon Hill and the high ground of the North Cotteswolds in the parishes of Broadway, Blockley and Cutsdean, and is present in Daylesford parish.

On Bredon Hill the Oolite dips to the south where it is locally faulted against Lower Lias clay. Consequently, the springs that issue from the base of the formation on the north face of the hill are small : such as there are, are mostly fed with water that accumulates in the débris of Inferior Oolite and slipped Upper Lias clay which renders the outcrop of the Upper Lias clay so hummocky. The springs issuing on the south side of the hill are, on the other hand, strong, and certain of them supply Westmancote and Bredon, some farms on the Bredon's Norton Estate, Kemerton, Overbury, and farms and houses on the Overbury Estate, Conderton and some neighbouring farms, and Grafton and Beckford in Gloucestershire. There is much surplus water running to waste.

In Broadway parish the prevalent dip of the rocks is from east to south-east—into the hills. Good springs, however, issue at Middle Hill and are used for the supply of Evesham and for private undertakings. But east of Broadway, on the slope of the hill, the bulk of the water that feeds the springs, as on the north face of Bredon Hill, comes from the accumulations of Oolite débris and slipped Upper Lias clay with which the outcrop of the latter is encumbered. Such is the origin of the springs that supply Broadway, and of Peartree Spring, which was the original source of supply of the Evesham and Pebworth Villages Joint Water Committee. In the Oolite in this parish is the Snowshill Clay that throws out small but useful springs, such as those that supply Seven Wells, Heath Farm and a lodge on the Spring Hill Estate. Wells tapping water held up by this clay-bed would have to be deepened with care, in case the thin clay-bed were penetrated and the supply lost. This same clay-bed is present in Blockley parish and holds up or throws out a limited but useful supply of water that has been drawn on by a number of farms and cottages—more in the past than at the present.

The bulk of the water absorbed by the Inferior Oolite, however, is thrown out at its base : springs abound in picturesque Dovedale and in Blockley village. Those at the head of Dovedale supply Blockley and were considered for Moreton in Marsh ; others give rise to streams that made it formerly possible to establish thirteen silk-mills in Blockley.

Fullers' Earth and Great Oolite

The beds referred to these Series occur in the parish of Daylesford. They include Chipping Norton Limestone, contemporaneous with a portion of the Fullers' Earth of the South-Western Counties, as well as beds of clay, marl and limestone belonging to the Great Oolite proper.

SUPERFICIAL DEPOSITS

Over considerable areas of the ' solid ' rocks in Worcestershire —and particularly on the Triassic and Lower Lias rocks—are patches of ' Drift,' or Superficial Deposits, of various sizes. These deposits are clays, sometimes tough and at others sandy (containing pebbles, débris and associated matter foreign to the district), gravel, quartzose sand, and along the rivers Alluvium.

True Glacial Boulder Clays occur here and there in and around the South Staffordshire plateau ; but only in relatively small areas to the east and south. Such are admirably displayed at California, near Harborne, and—more sandy types—in the neighbourhood of the Bristol Road at Northfield, and in the vicinity of Quinton. Fluvio-glacial sands and gravels, formerly spread out in front of the main face of the ice-sheet are met with at Moseley, Birmingham and Stourbridge. Subsequently the rivers removed portions of these, brought down more material, and arranged sand and pebbles in

terraces (River or Valley Gravels).[1] Still later, the principal rivers margined themselves with a fine sediment of Alluvium, now forming flat meadow lands liable to inundation in rainy periods.

The drift can usually be readily detected when on Keuper Marl or Lower Lias, for these formations do not include coarse sand and gravel but give rise to heavy red and bluish-grey clay-land respectively.

In this memoir the term ' Northern Drift ' is frequently used : it is applied to gravel largely composed of pebbles from the Bunter. The term ' Malvern Drift ' is applied to gravel lying east of the Malvern Hills that contains angular fragments, showing no sign of water wearing, derived from the Archaean of those hills.

The areas of sand and gravel—particularly those on the surface of the Lower Lias—have determined the original site of many a village. The deposit contained water—in limited quantity, it is true, in most cases—readily reached by shallow wells, and provided a dry site. But later, contamination of these sources, and in some cases the inadequacy of the supply for a growing village, rendered desirable the abandonment of the local sources of supply. In some instances more wholesome and sufficient supplies were sought farther afield, but where this was not possible rain-water storage was resorted to.

When taking samples of water for analysis it is desirable to say whether they come from wells which are in or penetrate superficial deposits. In the case of wells in Keuper Marl or Lower Lias tracts this is usually an easy matter, for the reasons given above ; but when the superficial deposits rest on Lower Keuper or Bunter Sandstones or Pebble Beds it is not so easy. One ready test, however, is that the Lower Keuper and Bunter Sandstones do not usually contain pebbles. In the case of the Bunter Pebble Beds differentiation is not essential, for the superficial deposits are generally of the same character as the underlying ' solid ' rock, their quartzose sand and pebbles having been largely derived from the Bunter Sandstones and Pebble Beds in the vicinity or not far away. Weathered Pebble Beds are often worked for gravel, so that a ' Gravel Pit ' marked on the Ordnance map may be in these beds and not in a superficial deposit.

The water from the sand and gravel, if not polluted, is usually of good quality. It will, however, be found that when the superficial deposit rests on Keuper Marl cases occur in which the water—particularly that issuing as springs—is irony, and when on Lower Lias, hard and ofttimes saline.

The latest geological deposits are Alluvium—mostly bordering the larger rivers—and peat. The level ground of the alluvium is rarely inhabited, because it is liable to inundation. Water from this deposit is seldom potable : it is affected by the peaty matter usually found associated with the silt.

[1] The distribution of superficial deposits forming river terraces alongside the River Avon is shown on a map accompanying Miss M. E. Tomlinson's paper : ' River-Terraces of the Lower Valley of the Warwickshire Avon.' *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, pp. 137–163.

III.—LOCAL DETAILS AND CONDITIONS OF WATER SUPPLY

The descriptions of these supplies are divided into two sections, each arranged in alphabetical order. The name of each parish, urban district, borough, or other unit is followed by the numbers of the maps in which it is included. These are arranged in three sets, denoting respectively :—

No. or Nos. of one-inch sheet, New Series (Ordnance or Geological) Map.

No. or Nos. of one-inch sheet or quarter-sheet, Old Series (Geological only) Map.

No. or Nos. of six-inch quarter-sheet (Ordnance or Geological) Map.

A list of those maps which are published with geological information is given in the Bibliography at the end of the volume.

Additional details regarding particular wells and springs are often to be found under the name of the parish or other unit in the serial List of Analyses, pp. 183 to 206.

A.—Civil Parishes included in Rural Districts.

In order to avoid too frequent repetition it may be stated here that in every parish, almost without exception, there are, locally, superficial deposits of sand and gravel resting on the older rocks.

Abberley.—Maps : 182 ; 55 N.E. ; 20 (4 quarters), 21 N.W.

The prominent Abberley Hill is a mass of Ludlow (Silurian) rocks. Resting unconformably upon them, between the village and The Hundred House is a mass of water-bearing Trappoid Breccia, while they are flanked to the north, north-west, and west by Old Red Sandstone, which under the village, and to the north-west and west is covered unconformably by Coal Measures. The coals in these are still worked, though not so extensively as in the past.

The following particulars of supplies have been communicated by C. Walker, Agent to the Abberley Estate ; those of the rocks from which the springs issue by W. Wickham King.

Abberley Hall Water Supply.[1]—Three springs, Nos. 1, 2 and 3, from the Upper Ludlow (? possibly with some Downtonian) are collected into brick tanks and led by gravitation through a 3-in. cast-iron pipe to Abberley Hall, West Lodge, The Apostles Oak, The Elms House, Oldgates, Game Kennels, Elbatch Lodge and Wilderness Farm.

An additional supply is obtained from springs south-south-west of Abberley village where the great thrust plane brings Lower Ludlow to rest upon Upper Ludlow rocks. The water is collected in a storage tank and open reservoir and pumped by steam pump into a brick-enclosed tank and an iron tank, each of 30,000 gallons capacity, situate on the north-west side of Flag Staff Hill, a little east of the hilly road to Abberley village. A pipe connection, controlled by a valve, from these tanks to the 3-in. pipe which supplies Abberley Hall, etc., allows water from this source to be used if the supply from springs 1, 2 and 3 fails. There is also a 6-in. pipe—called ' the fire main '—from the tanks direct to the Hall. Part of Abberley village is also supplied from these tanks.

[1] A. M. Kilby has control of this supply.

Abberley Estate.[1]—An enclosed brick tank at the junction of the Tenbury and Cleobury roads known as the ' Finger-post Tank,' is in Downtonian ground and supplies The Home Farm and Estate Sawyard. There is a connection between ' the fire main ' to Abberley Hall and the main from this to The Home Farm, so that in the event of necessity the whole supply can be linked up.

The ' Abberley Common Supply ' is derived from a spring on a well-marked N.–S. fault-line in Downtonian rocks, near the Apostles Oak House. The water is collected in a storage tank from which are supplied ' Rosedale,' The Nursery Cottage, a stand-pipe (for use of four cottages on ' The Common'), The Home Farm house, cottages 69–72, and North Lodge.

The brick tank east of the Schools, south-west of Tump Farm, is filled by a spring issuing from a group of N.–S. faults in the Coal Measures (Halesowen Group) under the tank. The tank is connected with another in Church Farm orchard built on the same dead level : an additional supply to these two tanks is obtained from the overflow of the large enclosed tank near the open reservoir of the Hall supply. The two tanks supply the Church Farm, Hill Head Farm, Beehive Farm, the two Beehive Cottages, and Old Leasow Farm.

Firleigh House is supplied from a small independent tank (near the reservoir of the Abberley Hall supply, and fed from the same springs).

Freemantle Farm, Town Farm, and part of Abberley village are supplied from ' Freemantle Tank,' on the east side of Flag Post Hill, fed by a spring rising in Downtonian ground in a trough bounded by two N. and S. faults.

Catterbutts, a small spring within a trough of Downtonian strata, is collected in a tank for the supply of the cottages along the road to Brook End.

The Royal George Inn, Upper Crundle Farm, and several cottages at Glazzard Green are supplied from a brick tank filled by a spring from a sandstone band in the Coal Measures (Halesowen Group).

Abberton.—Maps : 200 ; 54 S.W. ; 35 N.W., S.W.

The eastern portion of the parish is on Keuper Marl faulted against the Lower Lias that floors the remainder. The fault runs north and south through the village. Another fault runs east from this at the village, bringing a small patch of Arden Sandstone to the surface on its north side. The larger western portion of the village is on Lower Lias ; the rest on the Sandstone and Marl.

The parish is dependent on wells : there have been no complaints of shortage, but the water in many of the wells in the Lower Lias is saline, as remarked by H. B. Woodward,[2] and occasionally impregnated with sulphuretted hydrogen.

Abbots Lench.—Maps : 200 ; 54 S.W. ; 35 S.W., S.E., 42 N.W.

The low eastern part lies on Lower Lias clay, the western on Keuper Marl. From between these two formations crops out the Rhaetic Series.

The parish is sufficiently supplied by wells, but many of them are liable to pollution.

Abbots Morton.—Maps : 200 ; 54 S.W. ; 35 N.E., S.E.

On Keuper Marl. A fringe of Lower Lias occurs on the high ground on the south and south-east margin. The parish is dependent on wells.

Aldington.—Maps : 200 ; 44, 54 S.W., S.E. ; 42 S.E., 43 S.W., 49 N.E., 50 N.W.

Aldington parish is on Lower Lias clay, with overlying alluvium alongside the River Avon. Evesham and Pebworth Joint Water Committee's water is laid on to practically all the houses.

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[1] Owner, J. Arthur Jones.

[2] ' The Victoria History of the County of Worcester,' vol. i, 1901, p. 17.

Alderminster.—Maps : 200, 201 ; 54 S.E. ; 37 S.E., 44 N.E., S.E.

The greater portion of the parish is floored with the heavy clay land of the Lower Lias. From beneath the Lower Lias crops out the Rhaetic, and from below the latter the Keuper Marl, which occurs at the surface between the village and Alscot Park. There is alluvium along the River Stour. A boring at Alveston Hill, $3\frac{3}{4}$ miles due north of Alderminster Church—near Stratford-on-Avon—proved[1] :—

		Ft.
Soil and gravel		12
Keuper Marl (with probably a few feet of marly drift)		537
Lower Keuper Sandstone		149
? Enville Group	Sandstone, red (mainly)	30
	Marl, dark purple	26
		754

Particulars of a boring at Batsford, Lower Lemington, 9 miles to the south of Alderminster Church, are given on p. 1. From a consideration of these two borings it would appear that the Keuper Marl beneath the parish is from 500 to 600 ft. thick.

The parish is dependent on wells, and no shortage has been reported.

Alfrick.—Maps : 199 ; 55 S.E. ; 32 N.E., S.E.

Alfrick parish lies on a variety of formations. It is traversed, roughly from north-north-west to south-south-east, by an important fault by which Triassic rocks are let down against Palaeozoic rocks that form the hills to the west which are cut through by the Leigh Brook. The Trias consists of Keuper Marl, flooring the portion of the parish between the River Teme and Alfrick Church, and of Lower Keuper Sandstone and Keuper Basement Beds (breccia), which rise up from beneath the Marl along a narrow tract between the Church and Coppice End. The Silurian rocks west of the fault are anticlinally arranged, with May Hill Sandstone (upper part) and Tarannon Shales in the centre. Woolhope Limestone and Wenlock Shales succeed on the east side in a limited tract between Alfrick Court and Birchen Hall, but on the west side are continuous and are followed by the Wenlock Limestone and Ludlow Series. The Wenlock and Aymestry Limestones give rise to ridges locally dissected into knolls : the shales to valleys, with small springs —chiefly the product of surface drainage. The May Hill Sandstone is the best source of water : as at May Hill in Gloucestershire, the upper beds include many layers of clay and near the base of the succeeding Woolhope Limestone numerous small springs are found, many of them tapped in dip-wells. Wells sunk deep into the lower beds also usually yield a satisfactory volume of water.

The parish is adequately supplied by wells—dip-wells and wells fitted with pumps ; there are some draw-wells and several wind-pumps raising well or spring water.

Alfrick Court has a piped supply from the Silurian hill at High Wood, the Vicarage from a well in Keuper Marl, the water from which is raised by wind-pump. At the top of the hill west of Upper House, at Cross Hall, Garways Banks, is a well in May Hill Sandstone 42 ft. deep, with 12 ft. of water (16.2.'24). The house called Bewell is supplied from a well in the May Hill Sandstone aided by a windpump. At Lower Norgrove, by the side of Fanhouse Lane, a spring issuing from about the topmost beds of this sandstone has been bricked in and protected with a door by the Rural Council. Near by is an ' Eye Well '—a shallow dip-well—the water of which is used by some for bathing the eyes [2]. Another bricked-in spring with door occurs at the top of Crews Hill.

[1] See Dr. C. A. Matley, *Quart. Journ. Geol. Soc.*, vol. lxviii, 1912, pp. 271–273. Also ' Wells and Springs of Warwickshire ' (*Mem. Geol. Surv.*), 1928, pp. 140, 141.

[2] See L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), p. 139.

Alfrick Pound, mostly on the Woolhope Limestone, is supplied by wells fitted with pumps, that at The New Inn being used by a number of cottages. A little beyond the inn, on the south-east side of the road to Mousehole Bridge, is a pond fed by a spring issuing from the topmost bed of the May Hill Sandstone.

Birchwood Hall (in Cradley parish, Herefordshire) is supplied with water from the May Hill Sandstone of The Beck hill in this parish. The water is raised by windpump to a reservoir above the Hall.

At Birchwood Lodge, also in that parish, is another windpump over a well 75 ft. deep in May Hill Sandstone, while between Birchwood Hall and the Meeting House are two useful dip-wells catching water from the same formation.

Alvechurch.—Maps : 183 ; 54 N.W., N.E. ; 10 S.E., 16 (4 qrs.), 17 N.E., 23 N.E.

This large parish, except for a very small tract of Lower Keuper and Upper Mottled Sandstones, is on undulating ground of the Keuper Marl.

Since 1923 Barnt Green has been supplied in bulk by the East Worcestershire W. Co., except for certain houses owned and supplied by Birmingham Corporation, the parish having previously been dependent on wells and springs. The quality of the well-water, particularly in the village, was bad : of samples taken from 80 wells, supplying 159 houses with a population of about 700, only 12 were found fit for drinking purposes, 48 were unfit, and 20 suspicious.[1] The springs at Rowney Green were once suggested for supplying the village, but very wisely not made use of.

BORING AT SOUTHAN'S HOPWOOD BREWERY CO., LTD.

Made and particulars communicated by Messrs. C. Isler & Co. Ltd.

			Thickness. Ft.	Depth. Ft.
Dug well :—				
	[Soil, etc.]		6	6
Borehole :—				
Keuper Marl	1.	Red marl	40	46
	2.	Sandstone	3	49
	3.	Red marl	42	91
	4.	Blue stone and sandstone	3	94
	5.	Blue stone	9	103
	6.	Blue stone and red marl	21	124
	7.	Sandstone	6	130
	8.	Blue stone	1	131
	9.	Blue marl	7	138
	10.	Red marl and blue stone	9	147
	11.	Red marl	3	150
	12.	Clay	1	151
	13.	Blue stone	4	155

Lining.—40 ft. of 5-in. tubes, top 4 ft. below surface.
Rest-level.—68 ft. below surface. Yield.—400 gallons per hour.

Areley Kings.—Maps : 182 ; 55 N.E. ; 14 S.W., 21 N.W.

The parish is for the most part on the Bunter (Upper Mottled Sandstone) ; the village is at Areley Common and is on this rock. The succeeding breccias of the Lower Keuper Sandstone occur in patches, as at Dunley. Against the Upper Mottled Sandstone is faulted the Old Red Sandstone of Areley Wood, succeeded unconformably by Coal Measures in the valley of the Gladder Brook. Down by the Severn side is alluvium.

The chief houses—such as Areley Hall, Court and House, Swiss Villa—and the Schools have Bewdley water laid on ; otherwise the parish is dependent on wells and a spring or two. The ground being very undulating, the wells

[1] Dr. Coaker in County Medical Officer's Report for 1919, p. 86.

vary in depth according to position : thus some at Areley Common are over 100 ft. deep. Well supplies are plentiful, but liable—especially in the more populous parts such as Areley Common—to local pollution. A scheme, first mooted in 1914, but delayed owing to the War, is being considered of " stanking " [i.e., ponding] back the water of some springs in Botany Bay, below Stagbury (or Stagborough) Hill (see Ribbesford), and letting it gravitate to a reservoir on Birch Hill, to supply Areley Common. Some inhabitants of Dunley obtain water from a spring (issuing from Lower Keuper Sandstone breccia and owned by the R.D.C.) which discharges through a pipe by the road-side near the Dog Inn.

Broomy Hill.—A windpump about 500 yds. west of the church raises water for this house from a well 17 ft. deep in the Upper Mottled Sandstone.

Astley.—Maps : 182 ; 55 N.E. ; 14 S.W., 20 N.E., 21 N.W.

Except for the Silurian of the north-eastern end of Abberley Hill and a very small area of Upper Mottled Sandstone near Dick Bridge this parish is on much furrowed Lower Keuper Sandstone, with Basement Beds of breccia which are very well exposed in the lanes on both sides of Dick Brook, south-west of the church.

The parish is adequately supplied by springs and by wells which vary in depth according to situation. The well at The Pool House is about 40 ft. deep ; one at Mag Green Cottage about 80 ft.

' Prior's Well,' Astley, is a dip-well in a stone-lined recess at the bottom of the rectory garden, north-east of the church. The water comes from the Lower Keuper Sandstone from near its junction with the breccias of the Keuper Basement Beds. It is used by the rectory and farm-house near by, and is a relic of the demolished Priory of the Benedictine Order (founded A.D. 1080–86).[1]

Astley Hall and some cottages on the estate have water from a spring issuing from the Lower Keuper near the Pound Farm raised to them by a ram. The well at the Hall is 113 ft. deep. Yarhampton Farm and a few cottages have a gravitation supply from a spring in the Ludlow on the flank of Abberley Hill. Wordley Farm has a piped supply from an Old Red Sandstone spring to the north-west.

Badsey.—Maps : 200 ; 44, 54 S.E. ; 43 S.W., 50 N.W.

Situated on Lower Lias, and served by the Evesham and Pebworth Joint Water Committee's undertaking, practically all the houses having the water laid on.

Bayton.—Maps : 182 ; 55 N.E. ; 12 N.E., 13 N.W., S.W.

The western part of the parish is on ' Lower ' Old Red Sandstone, the rest, including the village, on Transition Coal Measures capped by an outlier of Trappoid Breccia and Old Hill Marls at Church Hill.

There is one coal-pit in work in the parish, on the Shakenhurst Estate ; the company is sinking a new pit on the Mawley Estate.

A boring [2] to the Main Sulphur Coal, made about 55 years ago at Carton Farm, north-east of Church Hill, went to a depth of 390 ft. 8 in., but there is no record of its yield of water.

Bayton village, School and Vicarage, Shakenhurst Hall, two farms and cottages derive their water (undertaking of the Exors. of the late Hugh Guerney) from the Trappoid Breccia on Colliers' Hill Farm, Church Hill, on the Mawley Estate. The daily average quantity is 2,200 gallons and the supply constant. The remainder of the parish depends on draw wells and wells fitted with pumps, the supply from which is moderate.

Nineveh.—This farm has water raised by ram from a spring issuing from the Old Red Sandstone.

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[1] See L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), p. 139.

[2] Referred to by E. A. N. Arber, *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, p. 380.

Bellbroughton.—Maps : 167, 182, 183 ; 54 N.W. ; 9 S.W., S.E., 15 N.W., N.E.

A large parish. Pebble Beds underlie Bell Heath and Money Lane ; Fairfield, Bell End, Bellbroughton village and Bradford House are on Lower Keuper Sandstone, while Doredale Green and the south of the parish are on Keuper Marl.

Fairfield is supplied in bulk by the East Worcestershire W. Co. through the meter near Bournheath. The remainder of the parish, dependent on wells, has adequate supplies in general, but there is local pollution. In the village pollution is the rule. (For more recent supplies, see Appendix, p. 215).

Bell Hall, on the Lower Keuper Sandstone, was once dependent on well and ram, but now gets the Company's water by a private extension from the Council's main near their building site at Fairfield.

Church House, Bellbroughton village.—H. J. Stobart informs me that he derives his supply from a borehole in the Lower Keuper Sandstone. He believes the borehole is 200 ft. deep and water rises to within 60 ft. of the surface—about 396 ft. above O.D.

Bentley Pauncefoot.—Maps : 183 ; 54 N.W. ; 23 N.W., S.W.

This parish lies west-south-west of Redditch on undulating ground of the Keuper Marl.

Upper Bentley is served by the East Worcestershire W. Co., but otherwise the parish is dependent on wells and a few springs.

Beoley.—Maps : 183 ; 54 N.W., N.E. ; 16 N.E., S.E., 17 N.W., S.W., 23 N.E., 24 N.W.

On Keuper Marl. The small village and parish generally are dependent on wells. The supply is usually adequate, but locally liable to pollution. Some of the waters are rather ferruginous.

Berrow.—Maps : 216 ; 43 N.E. ; 53 N.E., S.E., 54 N.W., S.W.

Except for Berrow Hill, a little outlier of Rhaetic capped by the basement-beds (limestones and clays) of the Lower Lias,[1] this parish is on the Keuper Marl in which the Upper Keuper or Arden Sandstone is developed.[2] The gravel spreads which extend from the west some way eastwards are largely composed of débris derived from the rocks of the Malvern Hills ('Malvern Drift ').

M. D. Price, Surveyor and Sanitary Inspector to the Upton-on-Severn Rural District Council, informs me that the wells at Hawthorns and Gatehouse Farms are in this ' Malvern Drift.'

The parish is dependent on shallow wells, the supplies in which are adequate, but generally contaminated.

Besford.—Maps : 199 ; 44, 54 S.W. ; 41 S.W., S.E.

Besford parish is on the Lower Lias clay. As is usual in such situations well-waters are mostly brackish and inadequate in amount at times.

According to Dr. G. H. Fosbroke, late County Medical Officer of Health,[3] 20.0 per cent. of samples analysed are reported to be ' fit for drinking purposes,' and the rest either ' unfit for drinking purposes ' or ' manifesting Past Contamination.'

Among the satisfactory sources is a garden well at the lower end of the village—the only one in that immediate locality which never runs short.

The two largest houses in the village have an ample supply brought down in pipes from the adjacent sand-bank, which is a good ' gathering ground.'

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[1] Richardson, L., *Quart. Journ. Geol. Soc.*, vol. lxi, 1905, pp. 425–430.
[2] Richardson, L., *Proc. Cotteswold Nat. F. Club*, vol. xv, pt. 2, 1905, pp. 93–100.
[3] Fosbroke, G. H., in Reports on the Water Supplies of . . . parishes . . . in the Pershore Rural District. Worcestershire County Council, 1910, pp. 32, 33.

Birlingham.—Maps : 199 ; 44, 54 S.W. ; 41 S.W., S.E., 48 N.W., N.E.

This parish lies for the most part on terraces of river gravel and sand,[1] resting on Lower Lias clay ; but margining the River Avon, and liable to flood, there is much alluvium. A useful spring issues from the terraces on the west side of the Eckington road, half a mile west of the church.

The parish is dependent on wells. According to Dr. G. H. Fosbroke,[2] these are sunk in gravel, but if sunk lower get into [Lower Lias] clay, when the water ' smells.' There does not appear to be any scarcity. Water is pumped a considerable distance from a well sunk in a field to the two local mansions, and the supply is said to be good. 62 per cent. of the samples [analysed] were reported to be ' fit for drinking purposes,' and 38.0 per cent. were either unfit or manifested past contamination.

Birtsmorton.—Maps : 216 ; 43 N.E. ; 53 N.E., 54 N.W.

This parish is on Keuper Marl, in which the Upper Keuper or Arden Sandstone is developed.

The parish is dependent on wells, some of which in the low-lying ground are very shallow. Supplies are adequate, but generally contaminated.

The well at the Schools is in gravel and the rest-level is about 4 ft. from the surface.

Bishampton.—Maps : 200 ; 54 S.W. ; 34 S.E., 35 S.W., 42 N.W.

A north and south fault, running east of the village, lets down Lower Lias on the west against Keuper Marl on the east.

The village is partly supplied by the Rural District Council from a well about 10 ft. deep (gravel resting on Lower Lias clay) at Niblett's Orchard, in the south-east angle of the cross-roads about 600 yds. south of the church. The water goes into a reservoir (roughly 15 ft. × 11 ft. × 10 ft.) close to the well, from which it is piped to a gravel filter and to the ' sump ' beneath the public hand-pump. At certain seasons of the year the water makes a yellow deposit of iron. Otherwise village and parish are dependent on wells in the Lower Lias clay, many of them yielding highly saline water. At certain times in the year the Council's is the only supply available in the village.

Blockley.—Maps : 217 ; 44 ; 51 S.W., 57 N.E., S.E., 58 (4 qrs.).

This detached portion of the county, lying south and south-east of Chipping Campden, Glos., includes and embraces portions of the Cotteswold Hills and of the vale at their foot. This vale is on Lower Lias locally covered by gravel. The Lower Lemington boring (p. 1) to Palaeozoic rocks was only a very short distance east of the parish boundary. The hills are formed of Middle Lias (Sandy Beds succeeded by Marlstone), Upper Lias (clay with thin Cotteswold Sands) and Inferior Oolite. The hill-country is furrowed by several combes — notably Norcomb, Dovedale, the combe at ' Far ' Upton Wold, and another to west of it.

Water is met with in limited quantities in the superficial gravel on the Lower Lias clay, also at the base of the Middle Lias, when it is sometimes chalybeate—for example, in Shoal's or Showell's Lane, 1¾ miles east by south of Blockley. It issues in great abundance from the base of the Cotteswold Sands in and around Blockley village ; and, in limited but still useful quantities, high up on the hills, where it is thrown out (or held up) by the Snowshill Clay in the Oolite Series.

The structure of the North Cotteswolds is such that away from the influence of faults and slips in the more immediate vicinity of Blockley village much of the rain that falls travels into the hill-country. Some of this water

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[1] Tomlinson, M.E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, p. 143, and pl. X.

[2] Reports on the Water Supplies of . . . parishes . . . in the Pershore Rural District *op. cit.*, pp. 34, 35.

ssues as strong springs near ' Far ' Upton Wold ; but the bulk works its way—mostly underground—down the valley of the River Dikler, ultimately emerging above Donnington Mill, 4 miles to south-south-east.[1]

Blockley.—This picturesquely-situated village is supplied by a spring issuing from the Cotteswold Sands below Hailstone Farm in Bourton Wood—near the head of one of the tributary combes of Dovedale. The water gravitates to a reservoir (capacity about 20,000 gallons) in Dovedale, from which it is laid on to the houses. The overflow constitutes the head-water of the stream that flows down through the Dovedale ponds.

Numerous other springs in the village issue from the same beds especially from the western side of the valley. Such are :—

(a) Dovedale Cottage Spring, which rises underneath the cottage and discharges a little below.

(b) Russell Spring, which flows from a spout in a stone erection repaired in the last century. The water is remarkably cold even in the hottest weather.

(c) Joyner's Springs, of which there are at least seven, discharge into the old silk-mill (later corn-mill) pond,[2] from the overflow of which a pipe leads to the Memorial Fountain (1838, repaired 1911), known in the village as ' Lion Spring ' ; but the bulk of the water runs into a pond and provides the power for generating the electricity with which the village is lighted.

(d) Bath Field Spring rises in The Bath Field and flows to The Bath Orchard, where, about the year 1846, one of the Roberts family who owned the land had a stone bath and building (both now in ruins) erected for private use. Fifty years ago both were in a fair state of preservation, and the bath was used occasionally by those who liked a dip in ice-cold water.

Northwick Estate.—A ram at the sheep-wash near the lower end of Norcomb with 1,900 yds. of rising main forces up water nearly 400 ft. to a reservoir near the west wall of the field in which The Holt Quarry is situate. This reservoir provides Upton Wold Farm with drinking water : for other purposes a good spring, thrown out by the Snowshill Clay in the Oolite Series, is available. A pipe runs from the same reservoir to a smaller one in The Holt Quarry, from which The Holt, Dovedale Farm, and certain fields have piped supplies ; there are also two shallow pump-wells at The Holt (tapping water held up by the clay-bed mentioned) used for purposes other than drinking.

Paxford.—The lower part of this hamlet is supplied by the Shipston-on-Stour Rural District Council from a spring rising there in gravel resting on Lower Lias clay. The supply is not always ample and the water is fairly hard. There is no storage reservoir, only service tanks ; the system of supply is somewhat complicated and probably in need of an overhaul.

The overflow from the private supply of " The Poplars " provides for the upper part of Paxford.

Draycott.—This supply belongs to the local property owner. Its source is a spring to the south of Draycott—between Oldborough and the targets of the Rifle Range. The water gravitates to a service tank at Oldborough, and thence to three or four stand-pipes used by most of the villagers ; recently a number of the cottages and farmhouses have been connected with the main. The quality is good.

Mineral Springs

Writing in 1875 (' The History of Blockley '), the Rev. Alfred J. Soden said :—" Some 24 years ago there were several chalybeate springs here very strongly impregnated. One of them at the lower end of Westmacott's Lane : of this spring there is now no visible trace, it having been built over. Another

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[1] See L. Richardson, *Proc. Cotteswold Nat. F. Club*, vol. xxii, pt. 2 for 1925 (1926), pp. 179–181.

[2] The silk industry was established in Blockley in 1700 by Henry Whatcott and at one t ime there were thirteen mills in work.

was in the Drying yard.[1] At the back of what is called Bath Orchard, there was a well called ' Blind Well,' the medicinal properties of the water being considered to be remedial in the case of weak eyesight. The writer has been informed that persons would come from a considerable distance to fetch the water from this well for the purpose of bathing the eyes."

WELLS

Troopers' or Dovedale Lodge.—At this lodge on the Broadway–Stow road are two pumps. One is over a well in Inferior Oolite said to be 90 ft. deep, in which there is very little water : the other over an underground tank of rain water collected from the roof.

Worcester Lodge.—Well fitted with a pump : " always plenty of water." This well would appear to tap water held up by the Snowshill Clay in the Inferior Oolite Series ; it is used also by the occupants of Springhill North Lodge when their own shallow-seated spring thrown out by the Snowshill Clay fails.

Bockleton.—Maps : 181 ; 55 N.W., S.W. ; 18 S.E., 19 S.W., 25 N.E., 26 N.W.

This parish is on high ground composed of " Lower " Old Red Sandstone. In it three brooks have their sources—Cadmore Brook, rising in Motlins Wood and flowing north-westwards to the River Teme at Berrington ; Cleaton Brook, rising near Romers Common and flowing south-westwards into the Stretford Brook, a tributary of the River Lug ; and Bockleton Brook, rising in the Birches meadows. These brooks are fed by a number of springs, which vary considerably in volume. The springs coming from the escarpment of the Birch Hill Limestone at Hill Farm are the most constant, but their waters are hard : some are petrifying springs.

The parish is well watered : water is said to be almost anywhere obtainable in wells at about 25 ft. down.

There are two rams—one forcing up spring-water to the Hill and Weston Farms ; the other brook-water to the Vicarage for other than potable purposes. The Bockleton Court supply is from a spring in a wood near the house and is raised by an oil engine to a reservoir at the top of the house.

Bransford.—Maps : 199 ; 55 S.E. ; 33 S.W., 40 N.W.

On Keuper Marl, on the surface of which are locally deposits of sand and gravel and, down by the River Teme, forming flat meadow-land, Alluvium. The parish is dependent on wells.

Bredicot.—Maps : 199 ; 54 S.W. ; 34 N.W.

This little parish, on the upper part of the Keuper Marl, above the Arden Sandstone, is dependent on wells ; no shortage has been reported. The old well at Bredicot Court is 35 ft. deep.

Bredon.—Maps : 216 ; 44 ; 48 S.W., S.E., 55 N.W., S.W., N.E.

This parish includes the hamlets of Hardwick, Mytton, Kinsham and Westmancote. It is for the most part on Lower Lias which is generally covered with sand and gravel of river terraces,[2] and, down by the Avon, with Alluvium. The smaller part is on the slopes of Bredon Hill, composed in ascending order, of Middle Lias, Upper Lias and Inferior Oolite. These beds on the south and south-west are faulted against Lower Lias.

Bredon village, Bredon's Hardwick,[3] and Westmancote (other than property belonging to the Norton Court Estate), have water laid on from an undertaking belonging to the Rural District Council. The source of supply is a spring, thrown out from the Inferior Oolite by the Upper Lias clay

[1] C.E. Belcher informs me that the site of the yard would appear to have been in front of the north-west portion of the Church and was either close to the church-yard or has been taken into it, and the spring covered over.

[2] Tomlinson, M.E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, pl. X.

[3] The well at Hardwick House is 35 ft. deep and is said to be through " gravel and sand " (? into Lower Lias).

beneath, at Spring Piece—up the western of the two head-combes of the valley that runs north from Kemerton. Here the water is received into a catch reservoir from which it goes to a service reservoir near Cherry Tree Cottage, 'Upper' Westmancote, whence it gravitates. The quantity, however, is becoming inadequate for increasing requirements.

The Norton Estate has water laid on to it from Sugar Spring—a spring issuing from much-slipped Inferior Oolite on Upper Lias clay in the broken ground between Aldwick Wood and the quarry on the hill-top. The surplus water feeds a trough and thence overflows down through Aldwick Wood. From Sugar Spring the water gravitates to a small reservoir (under a dense thicket enclosed by palings), marked 'W' on the 6-inch map, about half-way between the King and Queen Stones and Westmancote.

A well at the Council Cottages, Cheltenham Road, Kinsham, is 12 ft. deep in 'Northern Drift' and has an ample and pure supply of water standing at 5 ft. ex surface.

Bredon's Norton.—Maps : 199, 216 ; 44 ; 48 S.W., S.E., 55 N.W., N.E.

This parish adjoins the preceding on the north, and lies on similar rocks. The eastern extremity likewise embraces a portion of Bredon Hill.

Miss Martin's Norton Court property is supplied from a spring on the 400-foot contour-line, ¼ mile E.N.E. of the Court. The spring issues from much-disturbed Middle Lias Sandy Beds—blocks of Marlstone being prominent just above it. The water is tapped and run into a chamber at the source, whence it gravitates to a service reservoir in the Park some 150 yds. W. by N. Otherwise village (which is partly on Oolite gravel and partly on 'Northern Drift') and parish are dependent on shallow wells and a few small springs issuing from the 'Northern Drift.'

Bretforton.—Maps : 200 ; 44, 54 S.E. ; 43 S.W., 50 N.W.

On Lower Lias clay. A shaft sunk in search for coal about 1831 proved 300 ft. of Lower Lias without reaching the base.[1]

The village is on sand and gravel. The Evesham and Pebworth Joint W. Com. supply is laid on.

The Rev. J. E. H. Blake, formerly vicar, informs me :—"In the Vicarage garden, south-east of the village, and in fields close to, a very pure sand is got at about 2 feet or a little more from the surface. In winter this sand is full of water : in wet winters it is saturated to within 1 ft. 6 in. of the surface—in fact the water runs all through the soil at the level of the water in the brooks. This water is tapped by a number of wells, which until recently were the sole water supply of the village. Where the wells are still in existence and not polluted by surface drainage, the water is good and potable. We have such a well, which gives very good drinking water."

Bricklehampton.—Maps : 200 ; 44, 54 S.W. ; 42 S.W., 49 N.W.

Village on Lower Lias clay. There is no public supply. The private undertaking, listed as that of W. H. Bagnall, Esq., in the Local Government Board 'Return' (1915, p. 340), supplies all the cottages in the village excepting those "up the bank." The source of supply is gravel resting on Lower Lias clay 550 yds. north of Bricklehampton Church. The water is collected into a reservoir (about 10,000 gallons) and raised by a wind-pump. The daily average quantity obtained is 6,000 gallons. Otherwise the parish is dependent on wells, mostly in poor condition, in some of which the water is slightly saline.

Broadwas.—Maps : 199 ; 55 S.E. ; 27 S.E., 32 N.E., 33 N.W.

This parish is situate chiefly on Keuper Marl, but the greater part of the tract between the main (Worcester) road and the River Teme is on Alluvium.

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[1] 'Memoirs of H. E. Strickland,' by Sir W. Jardine, 1858, p. 83.

The parish is dependent on wells, mostly fitted with pumps ; the supply is, on the whole, adequate. Broadwas Court, formerly supplied by wind-pump from a well in Alluvium (?) and gravel, now has a piped supply from Nipple Well, Doddenham parish.

Broadway.—Maps : 200, 217 ; 44 ; 50 N.W., S.W., 57 (4 qrs.).

Broadway parish is situate partly in the Vale of Evesham and partly on the Cotteswold Hills. The vale portion is on the Lower Lias on the surface of which are gravel (of local origin) and quartzose sand, lying in a depression. Between the Station and the village, the bank to the north-east of the road is Lower Lias clay : to the south-west of the road is gravel, with veins of sand, which is worked in a pit.

In the hills crop out, in ascending order, Middle Lias (Sandy Beds and Marlstone), Upper Lias clay, Cotteswold Sands (thin), and Inferior Oolite ; but slipped Oolite débris, angular Oolite gravel, and slipped Upper Lias clay occur on the Upper Lias clay slope. In the Inferior Oolite Series is the Snowshill Clay. A deep valley runs into the hills southwards from Broadway past Snowshill (Glos.), and in its shallower southward continuation rises the River Windrush—a tributary of the Thames. Burrell Hill, to the west of this valley, owes its flat top to a capping of Marlstone.

Small springs issue from the base of the Sandy Beds ; numerous others, large and small, from the base of the Cotteswold Sands ; and small but useful springs are thrown out, as in Blockley parish, by the Snowshill Clay.

Broadway village has a public supply, the property of Evesham R.D.C. The source is in five springs issuing amid slipped Oolite and clay on the Upper Lias clay slope east of the village. Two of the springs are on the Farncombe estate : three have been purchased outright. One of these springs is called Todwell. The water is collected and piped to a service reservoir (about 25,000 gallons) constructed beside the road at the foot of Broadway Hill ; a smaller emergency reservoir lies alongside. But the storage capacity is inadequate : it holds " only half-a-day's supply," so that water has frequently to be transferred (through a meter) from the Evesham and Pebworth Joint W. Com. reservoir, adjoining. In the Local Government Board's 'Return,' 1915, it is stated that the average daily quantity obtained is 29,400 gallons and that a further 20,000 gallons per day could be obtained. From the reservoir the water is piped down the village and laid on to the houses.

Evesham and Pebworth Joint Water Committee (see p. 140).—Within the sharp southward bend of the Broadway–Stow road in its ascent of Broadway Hill is a depression into which gravitates water falling in the hollow under Armley Band [Wood]. Here formerly, amid slipped Oolite, rose Peartree Spring, now tapped, collected into chambers, and piped to the service reservoir (51,000 gallons) alongside those of the village supply. Thence it is piped to " Sandy's Arms " near which a junction is effected with the main from Lidcombe Wood. Previous to the acquisition of the Lidcombe Wood supply, Peartree Spring was the main feeder of the Evesham and Pebworth Joint W. Com. undertaking. Since it was tapped, the highest appearance of water at the surface occurs at the foot of the south retaining-wall of the road.

Fish Inn.—Water is obtained both from an underground reservoir, fed from the roof of the Dutch barn opposite the inn, and from a cattle-trough alongside Todwell—one of the sources of the Broadway supply.

Middle Hill.—Supplied from a spring, thrown out by the Upper Lias clay, below the mansion ; the water is raised by a ram.

The Rookery, Tower Barn and Broadway Tower, have water forced up to them by a ram at Middle Hill. The water enters a tank in the Tower or ' Monument,' and the overflow from this runs into a reservoir outside the Tower, from which it is laid on to Peter's Farm.

Heath Farm, half a mile S.S.E. of the Tower, is supplied from a spring, in the same field as the farm, which is thrown out by the Snowshill Clay in the Inferior Oolite Series, caught in a chamber, and piped to the farm. It is said to be a reliable spring.

Seven Wells.—About a mile S.S.E. of the Tower. The houses are supplied by a ' running ' spring thrown out by the Snowshill Clay. The overflow runs into a pond, and then sinks into the ' Harford Sands ' which underlie the clay-bed.

Spring Hill.—The house is supplied from a well sunk through Inferior Oolite down to the Sands and Upper Lias clay. The water is pumped up to a reservoir in a field and gravitates back to the house. The North Lodge is supplied from a spring, " poor in dry weather," thrown out by the Snowshill Clay ; the water is stored in a chamber and drawn from a tap near the lodge.

Broom.—Maps : 167, 182 ; 54 N.W. ; 9 S.W.

The village and most of the parish are on Lower Keuper Sandstone : a small part in the west is on Upper Mottled Sandstone.

The village is dependent on wells fitted with pumps ; but the well-waters in the parish as a whole are not too satisfactory owing to local pollution. A spring rising in the field to the east has been collected and piped to the road-side opposite to and for the use of the School ; while a few new houses have the Stourbridge and District water laid on.

Broom House.—Supplied from a well in Lower Keuper Sandstone, the water from which is raised by a petrol engine.

Redhall Farm.—Drinking water is obtained from a well (40 ft. deep and 25 ft. to water on 24th July, 1923) in the Lower Keuper Sandstone ; water for other purposes from a pool, from which it is forced up by a ram.

Broughton Hackett.—Maps : 199 ; 54 S.W. ; 34 N.W., N.E.

This parish is on heavy clay-land of the Lower Lias on the surface of which are sparsely-distributed quartzite pebbles (Drift).

The parish depends on wells, some fitted with pumps. Apparently the supply is adequate and its quality on the whole, satisfactory. Few brackish well-waters have been noted. Complaints are occasionally heard that the water makes a deposit on the sides of vessels when allowed to stand, which gives the impression that the vessels are dirty. Mr. Duncan informs me that such deposit is not unusual, and is probably mainly composed of calcium carbonate with organic matter. A trace of iron would also account for the brown colour.

Bushley.—Maps : 216 ; 44 ; 54 N.E., S.E., 55 N.W., S.W.

Sarn Hill and the hill at Bushley Park Farm are capped by the basal Lower Lias limestones, with alternating layers of clay and shale, resting on Rhaetic, outliers of which are represented on the Geological Survey Map as occurring south-west and north-west of the village. The rest of the parish is on Keuper Marl with local superficial gravel and flat meadow-lands on Severn Alluvium.

The village is for the most part on gravel—part of a river terrace that runs S.E. by S. to the main road. It is supplied mainly, and on the whole adequately, by wells mostly sunk in the gravel. Doublegate Farm, the Schools and School House, and the Vicarage have a piped supply from a covered reservoir (10,000 gallons) near the Post Office. The reservoir stores water from a very shallow-seated spring. Sarnhill Grange is supplied by ram from another shallow spring in a depression just north of Green Farm. Both supplies belong to the Rev. G. Berens-Dowdeswell of Pull Court. The houses at Wood Street draw on wells collecting water from the Lower Lias on the bank to the south-west and the water is accordingly hard.

Castlemorton.—Maps : 199, 216 ; 43 N.E. ; 46 S.E., 47 S.W., 53 N.E., 54 N.W.

Except for a small tract on the Malvern Hills, this parish is on the Keuper Marl, in which the Arden Sandstone is intermittently developed.

The parish is dependent on wells, the supplies in which are adequate but mostly polluted. A number of houses on Castlemorton Common obtain water from a stream which is maintained by compensation water from The Camp Reservoir (Malvern U.D.C.).

Some wells are very near the churchyard : one well in the Marl at the Council Cottages is 25 ft. deep (Analysis No. 134).

Chaceley.—Maps : 216 ; 43 N.E., 44 ; 54 S.E., 60 N.W., N.E.

This parish is on Keuper Marl with 'Northern Drift' and, alongside the Severn, Alluvium. The village is for the most part on gravel. The water-supply is obtained from wells, some of which, near the Severn, receive flood-water.

Chaddesley Corbett.—Maps : 182, 167 ; 54 N.W. ; 9 S.W., 14 N.E., S.E., 15 N.W., S.W., N.E.

This large parish lies for the most part on the Lower Keuper Sandstone. Keuper Marl occurs east of the village, and the Upper Mottled Sandstone crops out from beneath the Keuper Sandstone along a narrow tract in the north-west running from Mount Segg to Mary Knoll.

The village is on the Lower Keuper Sandstone and is supplied by wells, mostly fitted with pumps, the water in many of which is not very satisfactory owing to local pollution. One pump often serves a dozen houses. A scheme for boring at Bluntington for water to supply the village was discussed in 1914, but did not mature owing to the War.

Bellington Farm.—Good water from the brook is forced up by ram.

Bluntington House.—Well (80 ft. deep, 65 to 70 ft. to water in July, 1923); the water is raised by a wind-pump.

Bradford House.—Supplied from spring by ram.

Brockencote House.—Drinking water is obtained from a well fitted with a hand-pump : water for other purposes is forced up by a ram from a pool.

Fold Farm, in the village, is supplied from a well in Keuper Sandstone, 26 ft. deep and 10 ft. to water in July, 1923, the water being raised to large tanks by a windpump.

'Mary Knowle.'—Supplied from a borehole (see below), the water being raised by windpump.

Monks.—Water raised by petrol engine from a well in the Keuper Sandstone.

Sion House.—Supplied by ram from a spring.

Winterfold House and Estate.—Drinking water is forced up by rams from a spring : non-potable water by a ram, which also serves Brockencote House, from a pool.

Mustow Green.—On the Green is a public pump over a well.

BORING AT 'MARY KNOWLE,' KNOLL HILL, HACKMAN'S GATE [1]

Two accounts of the strata penetrated by this boring are available :—

1.—By W. Wickham King (supplied to the author).[2]

		Thickness Ft.	Depth Ft.
Lower Keuper	[? Sandstone]	34	34
Upper Mottled Sandstone	Soft, bright-red loamy sandstone ...	200	234
Pebble Beds	Coarse-grained, harder dull-red sandstone with a few minute pebbles and one 2 in. in diameter at base ...	66	300

[1] Sometimes spoken of as " at Blakedown."

[2] See also 'Thicknesses of Strata in the Counties of England and Wales' (*Mem. Geol. Surv.*), 1916, p. 139.

2.—By Messrs. H. Brown and Co., who made the boring in 1908.

	Borehole (diameter 4 in.) :	Thickness Ft.	Depth. Ft.
Lower Keuper Upper Mottled Sandstone and Pebble Beds	1. Hard sandstone	75	75
	2. Sandstone and marl	57	132
	3. Hard sandstone	4	136
	4. ' Cat-brain '...	6	142
	5. Hard sandstone	143	285
	6. Pebble bed	15	300

Rest-level.—145 ft. ex surface. Yield.—Full capacity of pump driven by windmill, 1,000 gallons per hour, but a much greater quantity of water could be obtained if required.

Charlton.—Maps : 200 ; 44, 54 S.W. ; 42 S.W., S.E., 49 N.W.

This is a long parish, mostly on Lower Lias ; but the western part of village and parish are on Keuper Marl with Arden Sandstone.

A considerable spread of sand and gravel, part of a river terrace, occurs in the northern part of the parish. It underlies part of the village, but is thickest in the vicinity of Fernhill Farm. A well at the farm is said to be 30 feet deep, but in the Charlton-Siding ' well ' the " good, always running " stream is at 12 feet down. The main outflow of water from this area is in the north-western portion—south-west of Fernhill Farm. The water is thrown out by the subjacent Lower Lias clay well above the level of the Alluvium that margins the River Avon—a fact which clearly indicates that the sand-gravel bed does not extend beneath the Alluvium. The actual area from which water could be conveniently collected from this sand-gravel bed would be less than might be at first sight expected ; it would be derived from a highly cultivated collecting ground, abstraction would soon exceed the natural recharge, and the removal of water would have a detrimental effect on cultivation.

Village and parish are dependent on wells and rain-water storage : a well at Strand Houses is 9 ft. deep and when examined had 2 ft. of water in it. As might be expected, the wells in the sand-bed yield an adequate supply of water. According to Dr. G. H. Fosbroke [1] 48.1 per cent. of the samples analysed were reported as fit for drinking purposes ; and two houses were ' certified ' under the Public Health Water Act until rain-water tanks were provided.

It is understood that the chief trouble here—especially when new houses are built on allotments—is that nitrates are high owing to manuring.

Boring at Haselor Hill

Made in 1922 and particulars communicated by Messrs. C. Isler and Co., Ltd.

Keuper Marl	Marl	110 ft.
	Arden Sandstone	

Supply.—1,000 gallons per day. The water comes from the Arden Sandstone.

Churchill (Worcester) [2].—Maps : 199 ; 54 S.W. ; 34 (4 qrs.).

This parish is on heavy clay-land of the Lower Lias, on the surface of which are sparsely-distributed quartzite pebbles and in one or two places—as at Churchill Wood (sand and gravel, 8 ft.)—thicker deposits of drift occur.

At the little village, on the clay, a number of wells were formerly in use, but all except one or two have been closed in favour of a well in an orchard some 150 yards north-west by north of the church.

[1] Reports on the Water Supplies . . . in the Pershore Rural District, *op. cit.*, p. 32.
[2] Pershore Rural District.

Churchill Spa [1] is situated on the south side of Spa Brook, ¼ mile north of the village and immediately to the left of the bridge. At the present time the ' Spa ' is a circular morass in the centre of which is a decayed wood stump through which the water overflows some 6 in. above ground-level. The water is much relished by cattle and is locally held to be " good for the eyes." On the six-inch map the water is recorded as chalybeate. Cecil Duncan says that it can be so described, but that it is also a salt water (Anal. Nos. 152, 152a, pp. 157, 177).

A spring, situate some 300 yds. south-east of Churchill Mill, is described as a " Petrifying Spring " on the six-inch map.

Churchill (Kidderminster).—Maps : 167 ; 54 N.W. ; 8 N.E., S.E., 9 N.W., S.W.

This parish is on Upper Mottled Sandstone, with the exception of a narrow tract of Pebble Beds that runs northwards from the west end of the little village.

The Stourbridge and District W.B. water was laid on to the village in 1915. The wells in the outlying portions of the parish are satisfactory in respect of amount and quality.

Church Honeybourne.—Maps : 200 ; 44, 54 S.E. ; 43 S.W., S.E., 50 N.E.

Lies entirely on Lower Lias clay. Served by the Evesham and Pebworth Joint W.Com. undertaking, practically all the houses having this water laid on.

Church Lench.—Maps : 200 ; 54 S.W. ; 35 S.W., S.E., 42 N.W., N.E.

There is gravel under the village, but the parish is for the most part on Lower Lias clay, from beneath which Rhaetic and Keuper Marl appear in the low ground between the village and Rough Hill Wood.

The parish is dependent on wells : there have not been any complaints of shortage, but the water in many of the wells is liable to pollution.

A suggestion was once made to impound the water of a streamlet, maintained by surface-drainage—on the south side of Rough Hill Wood—for the supply of Pershore.

Cleeve Prior.—Maps : 200 ; 54 S.E. ; 36 S.W., 43 N.W.

The village and most of the parish are on Lower Lias, beneath which Rhaetic and Keuper Marl crop out in the banks above the level of the Avon alluvium at Marl Cliff and Cleeve Hill. The Evesham and Pebworth Joint supply is laid on to all the houses.

Clent.—Maps : 167 ; 54 N.W. ; 9 (4 qrs.).

Clent parish extends from near Uffmoor Wood in a south-westerly direction to Blakedown. East of a fault, which runs from Hagley village to Bell Inn, are Coal Measures (in the north) overlaid by the Trappoid Breccia (estimated to be 450 ft. thick) that forms the well-known Clent Hills, followed by the Bunter Pebble Beds ; west of the fault is Upper Mottled Sandstone, with overlying Lower Keuper Sandstone between the Stourbridge—Bromsgrove road and Harberrow Common.

Clent village is a large one and is supplied by the Stourbridge and District Water Board. The outlying portions of the parish are dependent on wells and springs : many of these issue from the Trappoid Breccia at Adam's Hill. The streamlet in the deep valley between Walton and Clent Hills is ' stanked ' (ponded) back to form the picturesque ' Big Pool,' the overflow from which runs down the valley. Between The Vine Inn and the church is a ram that forces brook-water up to Clent Cottage.

' Moab's Wash Pot ' is simply a circular exceedingly muddy pond on the line of an old track-way on the summit of Walton Hill.

[1] See L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), pp. 149, 150.

St. Kenelm's Well is a small ' dip,' fed by a little spring (from Keele Beds according to Wickham King), beneath a stone which carries the footpath down the valley from St. Kenelm's Church. At one time the spring was accessible *in* the church, which was built over it ; subsequently it was reached from outside—by the recess under the East Window ; and yet later the present well became ' St. Kenelm's Well ' [1] (not to be confused with that at Winchcombe, Gloucestershire).

A stronger spring issues in a deep dell east of Chapel Farm, close to the church, but popular opinion favours the well described above as the source of the River Stour.

Clifton-on-Teme.—Maps : 182 ; 55 N.E., S.E. ; 27 (4 qrs.).

This parish is on Old Red Sandstone and mostly on the beds above the Birch Hill Limestone, which crops out along a more or less north-and-south line through Oldhills.

The village is supplied by an undertaking belonging to the Martley R.D.C. from a strong spring near Holloway Brook (the local name for the Sapey Brook), about one mile west by south of the village. The water is pumped by oil engine to a reservoir (25,000 gallons) north of the church, from which it gravitates to many houses and to stand-pipes in the village.

Ham (or Homme) Castle water-supply is obtained from a spring in the hill above the house and is just about sufficient for requirements. Hamcastle Farm, The Hope Farm, and Angestry Farms have gravitation supplies : otherwise the parish is dependent on wells.

Cofton Hackett.—Maps : 183 ; 54 N.W. ; 10 S.W., S.E., 16 N.W., N.E.

This little parish, depending on wells and springs, spreads over a variety of rocks : the north-eastern portion is on Keuper Marl, the central portion (in which is the Church) on Lower Keuper Sandstone, and the south-western extremity includes the south-eastern end of the Lower Lickey Hills with Lickey Quartzite (Cambrian) and the Barnt Green rocks (Archaean) of Kendal End. The Keuper is covered locally by clay and gravel—the latter thick in places.

Conderton.—Maps : 217 ; 44 ; 48 S.E., 49 S.W., 55 N.E., 56 N.W.

Conderton parish, like Overbury to the west of it, is narrow and extends from the top of the north face of Bredon Hill southwards to the Carrant Brook. Both parishes are traversed by the east-and-west fault that bounds this hill on the south. North of the fault is Inferior Oolite dipping southwards; south of it is Lower Lias with local hill-débris and Oolite gravel.

The hamlet is supplied, by an undertaking belonging to Holland Martin of Overbury Court, from a spring north of the hamlet, issuing from the Oolite, practically on the fault-line as represented on the Geological Survey map. The water is caught at its outburst in a reservoir (2,500 gallons), from which the overflow runs into a stone trough by the roadside and gives birth to a streamlet. There are taps in the village. The daily average quantity of water supplied is 2,000 gallons. (See also Overbury).

Cotheridge.—Maps : 199 ; 55 S.E. ; 32 N.E., 33 N.W., S.W.

On Keuper Marl ; Alluvium alongside the River Teme. The parish is dependent on wells, which vary in depth from 30 to 70 ft. Water from a well at Blackfield Farm smelt strongly of sulphuretted hydrogen.

Cradley.—Maps : 167 ; 62 S.W. ; 4 S.E.

Cradley parish is on Coal Measures. Some 1,386 houses out of 1,487 are served by the South Staffordshire W. Co. ; the rest depend on wells. Some

[1] A full account of the well, from original sources, is given by the late John Amphlett in his ' Short History of Clent ' (1890), pp. 7, 8, 177–193. See also L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), pp. 139, 140.

springs issue from the Halesowen Sandstone. " The Spout," in Spring Lane, by the road-side, discharges water coming from a hollow in the hillside above and was extensively used in the past. A spring in a closed roadside recess at Coleman's Hill was dry on 21st June, 1923.

The well at 154 Park Road (30 ft. deep, 18 ft. to water) was condemned for drinking purposes and the Company's water laid on Sept., 15th, 1923.[1]

A boring at the Fireclay and Brick Works of Messrs. King Bros. (Stourbridge) Ltd., went to a depth of 389 ft. in Coal Measures, the first 300 ft. being perhaps in Etruria Marl. All tubes were withdrawn.

Croome D'Abitôt.—Maps : 199 ; 44, 54 S.W. ; 40 S.E., 41 S.W.

Roughly speaking, the western two-thirds of this parish is on Keuper Marl ; the remainder on Lower Lias. The intervening Rhaetic beds crop out, in the bank which separates the two parts, along a north and south line through the church. The parish is dependent on wells. There have been no complaints of shortage.

Cropthorne.—Maps : 200 ; 44, 54 S.W. ; 42 S.W., 49 N.W.

This parish is on Lower Lias clay largely covered with gravel. The village is mostly on gravel and sand of a river terrace.[2]

Village and parish are dependent on wells, the supply being on the whole adequate, but locally polluted. A well (sunk Sept., 1923) in the village ¼ mile S.S.W. of the Church went through about a foot of gravel into Lower Lias clay (34 ft.). The water was found to be highly mineralized. A well at a new bungalow 1 mile S.W. by W. of the Church proved 12 ft. of gravel resting on the clay, and obtained an abundant supply.

According to G. H. Fosbroke [3] there seemed to be no scarcity in the greater part of the village, but 86.6 per cent. of the well-waters analysed were dangerous to health. " In the road leading from the main road (just below the ' New Inn ') to the brook, the water of the wells supplying 7 houses is not used, as the cottagers allege ' it is salt ' ; they consequently carry potable water from a spring in a field at a distance. A large house a little lower than these, has water laid on from a spring in a hill."

BORING AT CROPTHORNE MILL [4]

Made for Louis Barrow in August and September, 1922, and particulars communicated by him.

Boring (diameter, 4 ins.) :		Thickness Ft.	In.	Depth Ft.	In.
[Alluvium]	Grey clay	18	0	18	0
[Alluvial Deposits and ? Lower Lias]	Gravel				
	Blue-black clay and pebbles ...				
	Blue-black clay, pebbles and rough stone	14	3	32	3
	Blue-black clay—no pebbles ...				
[Lower Lias]	Dark blue-black clay	6	9	39	0
	Dark blue-black clay	1	0	40	0

Result.—No water met with at any point.

Well near Cropthorne Mill.—Mr. Barrow sank a well in the field to the east of the mill—on the left of the path to Cropthorne just before it crosses the footbridge. The record of this well-sinking is that given by Miss Tomlinson,[5] but it is erroneously described as a boring and Mr. Barrow informs me that the ' Alluvial brown silt ' is 1½ ft. thick and not 18 ft.

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[1] Particulars from J. W. Cox, Sanitary Inspector.
[2] Tomlinson, M. E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, Pl. X.
[3] Reports on the Water Supplies . . . in the Pershore Rural District, *op. cit.*, pp. 30, 31.
[4] Converted into a private house. The borehole is in the garden.
[5] *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, p. 153.

Well (diameter, 6 ft.) :		Thickness Ft.	In.	Depth Ft.	In.
[Alluvial deposits]	Alluvial brown silt	1	6	1	6
	Bright blue marl, with occasional flints (many flints about 4 ft. down)	16	6	1	6
[Old River Gravel]	Orange-coloured gravel	Thickness not stated.			

Result.—Water had earthy taste and was so opalescent that the well was filled in.

Crowle.—Maps : 199 ; 54 S.W. ; 29 S.W., S.E., 34 N.W., N.E.

In the steep bank below Crowle Green crops out the Rhaetic Series (yellowish-green marls overlying black shales) along with the top of the Keuper Marl, which forms the low ground at the foot of the bank. The village and greater part of the parish east of the bank, are on Lower Lias. Pebbles of quartzite (Drift) are sparsely distributed over the whole surface.

The parish is dependent on wells, most of them polluted. Of 91 samples once examined 55 were unfit for domestic purposes, and 11 suspicious.

In wet weather there are numerous land springs : for example, those discharging through pipes into the ditch alongside the road from Crowle to Himbleton, opposite the Mission Hall.

Candy Well[1] at the roadside ¾ mile north-east of Crowle Church, is a bricked " dip," receiving water piped from a field to the west. It is a strong spring of good water, excellent, Mr. Duncan informs me, in comparison with the water usually found in the Lower Lias tracts of the county, which could be used for the supply of Crowle, though it would have to be pumped ; it never fails, and yields 275 gallons per hour in the driest weather. Personal inspection showed me that it has a comparatively large collecting area, and comes, perhaps mainly, from limestone in the Lower Lias together with surface drainage.

Crutch.—Maps : 182 ; 54 N.W. ; 22 N.W., S.W.

This sparsely populated little parish is on Keuper Marl, with traces of gravel (Drift). It is dependent on wells, the water in which is said to be sufficient and good.

Crutch Farm.—Herbert Bird, Agent to the Westwood Estate, near Droitwich, informs me that a well sunk in the Keuper Marl here, 55 ft. deep, gave 3 ft. 7 in. of water in 14 hours in an opening 4 ft. 6 in. in diameter. Another well, sunk to a depth of 57 ft. 6 in., yielded only a slightly better supply. He then decided to bore. The borehole, 83 ft. deep and 5 in. in diameter, gave another 18 in. of water. The last 49½ ft. of marl was so hard that it had to be blown by gelinite ; but no sandstone was struck. The water is quite good, although at times saline, but not when the pump is kept working regularly. Crutch Farm is one mile north by west of the subterranean " brine stream " course at Ford Farm (see p. 105).

Cutsdean.—Maps : 217 ; 44 ; 57 S.W., S.E., 61 N.W., N.E.

This parish, high up in the heart of the North Cotteswolds and completely surrounded by Gloucestershire,[2] is bounded on the west by the Windrush Valley ; on the east by the ' Beechy Bank Valley,' the former excavated down to the Upper Lias, the latter almost thereto.

The village has a piped supply, forced up by a ram *via* Taddington, from a spring to the west in Lidcombe Wood, Stanway, Glos.

The Inferior Oolite, which succeeds the Upper Lias, floors the parish between the valleys named. The subdivision that mostly occurs at the surface is the Chipping Norton Limestone, formerly worked in places for a rough tilestone. In the Inferior Oolite, approximately between the Freestone

[1] Locally called " Caudy " Well.

[2] This chapelry was given to the Church of Worcester by Offa, King of the Mercians, and was attached to the parish of Bredon, Worcs.

and Ragstone divisions is a bed of clay known as the Snowshill Clay ; and locally, resting on the Chipping Norton Limestone, are traces of tough Upper Estuarine (basal Fullers' Earth) clay. The Snowshill Clay, which cannot safely be assumed to be more than 12 ft. thick, throws out a spring some 220 yds. S. by W. of Scarborough : this is piped to a reservoir at Scarborough from which the house and Cutsdean Lodge are supplied. Hinchwick, in Condicote parish, Glos., has a piped supply from another spring towards the top of the bank 730 yds. to the northward. The Hinchwick supply spring issues through a pipe a little above the reservoir. Fragments of rock lying about near the reservoir, and presumably from the excavation which holds it, are of Notgrove Freestone with a few pieces of typical *Clypeus*-Grit. It would therefore appear that this spring is thrown out by a clay-bed higher in the series than the Snowshill Clay, and perhaps above the *Clypeus*-Grit. On the other hand a small spring 270 yds. N.W. by W. is thrown out by Snowshill Clay, for the underlying Harford Sands are exposed at a slightly lower level to the S.S.E.

On the Chipping Norton Limestone ground north-westward of Hinchwick Hill Barn water for the cattle is collected in cement-bottomed dew-ponds.

Daylesford.—Maps : 217, 218 ; 44 ; 62 S.E., 63 S.W.

Another entirely detached parish extending over Lower, Middle and Upper Lias, Inferior Oolite and Great Oolite, all disturbed by faults. On the surface of the Lower and Middle Lias, up to about the 400-ft. contour line, local deposits of Glacial sand and gravel have been worked.

A. E. Clifford, District Surveyor to the Stow on the Wold Rural District Council, informs me that the village is on clay with veins of sand and gravel. Village and parish are supplied by gravitation water, belonging to C. E. B. Young, from a spring on Daylesford Hill, thrown out from the Oolites by the Upper Lias clay. There is a tank at Daylesford of 2,000 gallons capacity.

Defford.—Maps : 199 ; 44, 54 S.W. ; 41 S.W., S.E., 48 N.W., N.E.

On the Lower Lias. The sand and gravel deposits are mostly remains of river terraces. Alluvium margins the River Avon and the Besford Brook up to Defford Bridge. Defford Common, on the Lias clay, is the last remnant of the ancient forest of Horewell and the largest waste tract in Worcestershire.

The village is on mixed clay, sand and gravel, the surface deposits being thin. It is dependent on shallow wells and a public pump by the side of the Pershore road near the Crown Inn belonging to the District Council. Locally during dry summers only, a few householders have to resort to the public pump. Of the well-waters sampled, however, only 7.6 per cent. were said to be ' fit for drinking purposes,' and 69.2 per cent. were either unfit or showed past contamination.[1]

J. J. Jacques, the Sanitary Inspector, says that the analysis given (No. 182, p. 158) referred to a well practically in the centre of the village. Some wells yield mineral waters : that at the School does and it is very hard. The well-waters at Woodmancote are also ' brackish.'

H. B. Woodward says[2] :—" H. E. Strickland in 1842 drew attention to some old salt works on Defford Common, mentioning that seventy years previously (about 1770) a shaft was sunk to a depth of 175 feet, and that brine then overflowed. The lowest bed penetrated was the grey marl of the Triassic series, which occurs at the top of the red [Keuper] marl." The occurrence of this weak brine has been referred to frequently by authors, but the probability is that it came from the Lower Lias and was of the character of that so frequently met with in that formation.

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[1] Fosbroke, G. H., Reports on the Water Supplies . . . Pershore Rural District, *op. cit.*, p. 43.

[2] The Victoria History of the County of Worcester, vol. i, 1901, p. 17.

Doddenham.—Maps : 199 ; 55 S.E. ; 27 S.E., 32 N.W., N.E.

Mostly on the Keuper Marl. The Lower Keuper Sandstone rises locally to the surface in the west, and beyond it an important fault throws up the May Hill Sandstone of Ankerdine Hill locally overlain by Trappoid Breccia. The level meadows alongside the River Teme are on Alluvium.

The parish is adequately supplied by wells and springs, but some cottagers on Ankerdine Hill have to carry water some distance. At ' The Tower House,' on the Hill, is a deep well in the May Hill Sandstone. The water is raised by electric pump to a tank at the top of the tower of the house, and a tap was formerly provided by the road-side for local public use ; but water has now to be fetched from the public pump, at the side of the path-way to the left of the entrance to the Sanatorium, which draws from the May Hill Sandstone of the surrounding depression. Before 1902 the water was tapped in an open dip well.

Knightwick Sanatorium for Consumption.—This institution has Teme water pumped up to it and chlorinated. The water is also laid on to two houses near the lodge. The supply formerly obtained from a well in the May Hill Sandstone, marked by a derelict windpump, was inadequate.

Collins' Green.—Most of the houses are on the Trappoid Breccia, possibly with some Coal Measure clay beneath, such as that temporarily displayed in low banks of the track at The Bank Farm. The deep valley below and east of this farm marks the important fault already mentioned. The Triassic rock along part of this fault is Lower Keuper Sandstone, from which, and close to the fault, issue a number of springs, the most important being Nipple Well.

Nipple Well.—This spring, well known locally as a ' Wishing Well,' is derived from the drainage of a portion of the eastern slope of Ankerdine Hill and emerges, close to a fault, from red Lower Keuper Sandstone. It now first runs into a chamber from which there is a pipe to Thorney and Banners Brook Cottages and Broadwas Court (formerly supplied from a well with windpump), but a good, continuous overflow greatly augments the streamlet that comes down the valley and eventually discharges into the River Teme near Bannersbrook Farm.

(Upper) Gurnox.—A well here in the Keuper Marl (with gypsum) is 103 ft. deep and 83 ft. from the surface to the water. The water smelt and tasted so objectionably of suplhuretted hydrogen that a supply had to be obtained from a spring in the valley to the north. The spring water is caught in a chamber and raised by a windpump a short distance away to a tank at the house ; its overflow is the principal source of the stream in the deeply-cut valley at Devil's Leap, near which it is joined by another stream, the water of which is hard and forms travertine. Lower down a number of small springs —probably coming from hard layers in the Marl—contribute to the stream which eventually enters the Teme near Doddenham Court.

Dodderhill.—Maps : 182 ; 54 N.W. ; 22 (4 qrs.).

On Keuper Marl [1] with local Drift (sand and gravel).

The village (at Wychbold) and the houses within some 300 or 400 yds. of the Bromsgrove–Droitwich road have East Worcestershire water laid on. The outlying portions of the parish are dependent on wells, most of the old ones being from 70 to 200 ft. deep : that at Rashwood House—which is supplied with Company's water—is 90 ft. deep. W. H. Barnes, of Rashwood House, informs me that there are few, if any, genuine springs, and that the wells in this neighbourhood are closed where possible in favour of Company's water, because of the hardness of the well-waters.

Impney Park.—The mansion has Company's water laid on : the water-tower in the Park has water pumped to it from a well for use in the gardens.

[1] The main Droitwich–Stoke Prior brine course traverses (below ground) this parish (see p. 105).

Dormaston.—Maps : 200 ; 54 S.W. ; 30 S.W., 35 N.W.

Dormaston parish is on Lower Lias clay, in which there is a well 30 ft. deep at Coneybury Farm, and a mineral spring. It is dependent on wells, ponds, and rain-water storage. The supply is inadequate in summer and none too satisfactory as regards quality.

Doverdale.—Maps : 182 ; 54 N.W. ; 21 N.E., S.E.

The greater part of this parish is on Keuper Marl, which is cut off by a fault running N.N.W. through the church and Southall. Springs issue near the church from the Lower Keuper Sandstone brought up by the fault. Locally there are traces of surface gravel and sand.

The parish is dependent on wells, the water in which is said to be sufficient and good.

Dowles.—Maps : 167, 182 ; 55 N.E. ; 7 S.E., 8 S.W., 14 N.W.

Part of this parish, to the west of the River Severn, is on the lower barren portion of the Middle Coal Measures (Sweet Coal Series) [1], which rests on Lower Old Red Sandstone. If bored into, the Old Red would probably yield salt-water as at the boring in Bewdley Borough near Oak Cottage (see p. 96). Old Red Sandstone also occurs at the surface east of the Severn around Hill Farm ; and Alluvium, formerly dug for brick-making, at Dowles Brick Works, fringes the river.

The parish is dependent on springs and wells of satisfactory purity ; but in the drought of 1921 practically all the wells went dry. The springs utilised by a number of bungalows are out of reach for the permanent houses.

Dowles Farm is supplied by a well and pump, and by ram from Dowles Brook.

Earls Croome.—Maps : 199 ; 44 ; 47 N.E., S.E., 48 N.W., N.E.

Except at its eastern extremity, which is on the bank where the Rhaetic and basement-beds of the Lower Lias crop out, this parish lies on Keuper Marl, mostly above the Arden Sandstone. Though dependent on wells there have been no complaints of shortage.

A well in the Marl at Hollybeds Farm (160 ft., O.D.) 116 ft. deep and 5 ft. in diameter, usually has about 28 ft. of water in it. Another at the Rectory, close to the Church (about 55 ft., O.D.), is shallow.

Eastham.—Maps : 181, 182 ; 55 N.E. ; 19 N.E., S.E., 20 N.W.

On Old Red Sandstone, covered alongside the River Teme by Alluvium. In the valley the Old Red beds are principally red marls ; but on the hills they are chiefly sandstones resting on the Downtonian or Birch Hill Limestone —locally called ' The Limestone.' Much water is met with in the sandstones, but the majority of the springs issue from ' The Limestone ' from which they are thrown out by the marls below.

The parish is dependent on wells and on springs from which there are numerous small private piped supplies. Those mentioned below are gravitation supplies, the first two derived from the sandstones, the remainder from ' The Limestone.'

Hillwood Farm.—From spring a 100 yds. or so south of the farm.

Hill Top.—From spring about ½ mile to the east by north.

The Grange.—From spring about ½ mile to the west by south.

Stonehouse Farm.—From spring about ⅛ mile to the south. There are strong springs above this farm.

Lower House Farm.—For cattle drinking troughs only—from spring about ½ mile to the south.

Ferneyhill.—From a weak spring.

Court Farm is supplied from a spring near The Flats at Eastham. Two cottages near the Church derive their supply from this pipe line.

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[1] Arber, E. A. N., *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, pp. 431, 432.

Eckington.—Maps : 199, 200 ; 44 ; 48 (4 qrs.).

The greater part of this parish is on Lower Lias clay, with a noticeable terrace of river-deposited gravel [1] which is thickest to the west of the main road through the village, and thins away to the east, the Lower Lias clay appearing from beneath it at Upper End. The broad alluvial meadows along the River Avon are submerged in flood time. The parish embraces a portion of the side of Bredon Hill, in which occur Middle Lias (Sandy Beds succeeded by Marlstone), Upper Lias and Inferior Oolite. Numerous small springs issue near the 700-foot contour line from the base of the Oolite and a few from the Sandy Beds of the Middle Lias. The parish is dependent on wells, springs, and rainwater tanks.

The portion of the village on the gravel is sufficiently supplied with water ; but not that on the clay (Upper End). There is a public pump, put in by the Sanitary Authority in 1894, over a well in the gravel in Bunn or ' Boon ' Street, some 350 yds. west of the Church. The quality of the well-waters, however, is unsatisfactory and only 29.7% of samples taken were found fit for drinking purposes.[2] At the Vicarage, partly beneath the house and partly under the garden, is a well of large diameter the water in which smells of sulphuretted hydrogen—a defect of common occurrence at Upper End where the water is, in addition, brackish.

Woollas Hall is supplied with water from the base of the Middle Lias Sandy Beds at the foot of a steep bank. The Marlstone is well exposed in a quarry on the 600-foot contour line, a quarter of a mile east of the Hall : 1⅛ miles to the S.W. (near Norton Court) it occurs just above the 400-foot contour.

St. Catherine's Well, between Woollas Hall and the tower on the summit of Bredon Hill, lies near the foot of the steep escarpment of the Inferior Oolite, and is merely a semicircular recess backed with a wall of loose Oolite stones, with the water at the foot. A little lower down a stronger spring gives rise to a rill that persists down into the vale.[3]

Eldersfield.—Maps : 216 ; 43 N.E. ; 53 S.E., 54 S.W., S.E., 60 N.W., N.E.

On Keuper Marl, with well-developed Upper Keuper (Arden) Sandstone, the sinuous outcrop of which shows clearly the flexing that the rocks have undergone. The Church is on the Sandstone.

The parish is dependent on wells, the supplies in which are adequate but mostly polluted. On Eldersfield Marsh the wells are shallow.

At Link End Farm, nearly 2 miles east of the Church, a new well (25 ft. deep) replaces an older unsatisfactory supply (Analysis No. 218).

Elmbridge.—Maps : 182 ; 54 N.W. ; 15 S.W., 22 N.W.

On Keuper Marl with traces of gravel (Drift).

The parish is dependent on wells, the water in which is said to be sufficient and good.

Elmley Castle.—Maps : 200, 217 ; 44 ; 48 N.E., S.E., 49 N.W., S.W.

On Bredon Hill, in the south-west, crop out Middle Lias, Upper Lias clay and Inferior Oolite ; the rest of the parish is on Lower Lias clay. All the formations in the hill have undergone local slip. The prevalent dip is southwards, and the bulk of the rain that falls on the Oolite of the hill-top sinks through that rock and travels southwards along the dip-slope of the underlying Upper Lias clay into Overbury parish (q.v.) ; on the northern hill-slope the small springs that issue near the junction of Oolite and clay are mostly the outburst of water accumulated in slipped rock. The bulk of the water

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[1] Tomlinson, M. E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, Pl. X.

[2] Fosbroke, Dr. G. H., Reports on the Water Supplies . . . in the Pershore Rural District, *op. cit.*, pp. 33, 34.

[3] See L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), pp. 141, 142.

that comes from Elmley Lodge and feeds the picturesque ponds in Elmley Park is so derived. On the other hand, none of the water in the Middle Lias finds an outflow in Overbury, and a good spring from these strata issues in the ground called ' Cleminscroft ' ½ mile W. by N. of Elmley Castle Church.

Elmley Castle village is for the most part supplied from this spring by an undertaking provided by Major-General F. J. Davies. The water gravitates from a reservoir to the village, in which it is laid on to a few houses and to standposts. The supply has run low at times, but on the whole suffices. The outlying parts of the parish are dependent on wells. Water from one of the village taps was partially examined in 1894 by E. W. T. Jones, and was reported as " free from sewage or animal pollution and a good water for drinking and domestic use." [1]

A water-boring made in 1923 in slipped Middle Lias Sandy Beds, below the north-eastern portion of Elmley Wood, was unsuccessful. The slipped sandy clays were penetrated and then apparently *Capricornus*-Beds (Lower Lias) were entered.

Elmley Lovett.—Maps : 182 ; 54 N.W. ; 14 S.E., 15 S.W., 21 N.E., 22 N.W.

The greater part of the parish, including the village, is on Keuper Marl but not far above its base, for Lower Keuper Sandstone appears from beneath it east of the village at Bradford House and is faulted against it east of Acton Hall. There are traces of Drift gravel.

The parish is supplied by wells, the water being reported as sufficient and good.

Evenlode.—Maps : 217 ; 44 ; 58 S.E., 62 N.E., S.E.

This ' detached ' parish is on Lower Lias clay with local Glacial sand and gravel. The village is mostly on the clay but partly on gravel, and dependent on wells, which yield an adequate supply. Evenlode Grounds Farm, until recently glebe property, has a piped supply from a spring in the adjoining Adlestrop parish (Glos.). In one of the glebe fields (' Shepherd's Ground '), near the railway-bridge on the Broadwell road, there is a useful spring running to waste.

Feckenham.—Maps : 183 ; 54 N.W., S.W. ; 23 S.W., S.E., 30 (4 qrs.).

Except for a small area of Lower Lias in the extreme west, roughly between Littleworth and Priest Bridge (over the Brandon Brook), this parish is on Keuper Marl. On this, locally, lie sand and gravel, as along the Ridgeway (the high ground at the east side of the parish), west of which the country is deeply furrowed by the head-streams of the Brandon Brook, and in places—as near Astwood Court—small springs issue from the surface deposits.

Astwood Bank and Feckenham village are supplied by the East Worcestershire Waterworks Company. A main runs from the Headless Cross reservoir to Crabbs Cross, whence there are three pipe-lines (1) to Studley (Warwick), (2) to Astwood Bank and (3) to direct customers, mostly in Crabbs Cross. The rest of the parish is dependent on wells, the water being adequate, but in many cases badly contaminated. The wells are mostly shallow, but one at the ' Concrete Cottages,' on the east side of the Evesham Road about ¼ mile south of Astwood Bank, is at least 120 ft. deep, with water standing at 90 ft. down.

Coming from the Lower Lias at the eastern foot of Burrow Hill is a small spring, said to be ' salty.'

Sillins.—A ram pumps water from the brook to this house.

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[1] Marten, E. B., ' Report . . . Supply for the Town of Pershore,' p. 15, and G. H. Fosbroke, ' Report . . . Pershore Rural District,' *op. cit.*, p. 59.

Fladbury.—Maps : 200 ; 54 S.W. ; 42 N.W., S.W.

Fladbury parish extends over Lower Lias, small patches of Keuper Marl and Rhaetic beyond the fault at Craycomb, sand and gravel of two river terraces (resting on Lower Lias), and, alongside the River Avon, Alluvium.

The ' sand-bed ' that occurs in this parish is part of an important stretch that extends westward through the parish of Moor and into that of Wyre Piddle. It is here considered as a whole. Wells in the ' sand-bed ' of the upper terrace (No. 2 of Miss Tomlinson's classification) [1] indicate that the deposit does not exceed 15 ft. in thickness and that the depth of water in the deposit does not exceed say 4 ft. The outflow of water (1) north-east of the School, Fladbury, (2) at Springhill Farm, and (3) half a mile eastward of the Church, Wyre Piddle (the spring used to supply Wyre), show that (1) the ' sand-bed ' rests on clay (Lower Lias), and (2) that the ' sand-bed ' does not extend down beneath the Alluvium. The main outflow from this ' sand-bed ' is at Springhill Farm and is the product of an intensively-cultivated and liberally-manured collecting-ground. It may be stated here that the lower ' strata ' of water in ' sand-beds ' resting on Lower Lias are frequently highly saline.

At a slightly lower level than the above river terrace is another (No. 1 of Miss Tomlinson's classification) composed of gravel and clayey matter. Its clayey nature is such as to indicate that it is unlikely that it is a good water-bearing deposit. It may extend in an attenuated form for some distance beneath the Alluvium in the direction of the river. This, however, is doubtful, but assuming that it does and that a well were sunk through the Alluvium to its attenuated development it is practically certain that the water would be unsuitable as regards quality, that adequate recharging through the clay-gravel would not take place, and that no recharging could be looked for from the river through the extremely clayey Alluvium.

Fladbury village is on the sand-bed of No. 2 terrace and is supplied by wells up to 20 ft. in depth. The well at the first cottage on the left (east) at the Fladbury village end of Broadway Lane is 14½ ft. deep and when examined had 2½ ft. of water in it ; and that at the houses known as ' Broadway Lane ' (on the east side of the lane at Broadway), 9 ft. deep (4 ft. of water). The quantity of water in the wells is generally sufficient, but Dr. G. H. Fosbroke reported that only 22.3 per cent. of the samples were ' fit for drinking purposes ' ; of the others one had been polluted by fish manure.[2]

Flyford Flavell.—Maps : 200 ; 54 S.W. ; 35 N.W., S.W.

This parish, on the Lower Lias clay, is entirely dependent on wells, from 10 to 12 ft. deep. The supply is on the whole adequate, unless the season is very dry. The water of several wells in the village is brackish and used only for cleaning purposes.

Frankley.—Maps : 168 ; 54 N.W. ; 10 N.W., S.W.

Frankley parish is on much-faulted Upper Coal Measures (Halesowen and Keele Beds), with an outlier of Trappoid Breccia (Enville Beds) at Frankley Beeches. It touches the north-western extremity of the Lower Lickey Hills at Rubery.[3]

A main from the Frankley Reservoir of the Birmingham Corporation supplies the houses from Frankley Church up as far as the Schools ; but otherwise the parish is dependent on wells, the water being reported as satisfactory in quality and amount.

Kit's Well, near Kitwell House, on the northern boundary, is a square, brick-lined well beside the road, and is indicated as chalybeate on the 6-inch map. It derives its water from a streamlet flowing into the River Stour from a depression near the ' divide ' between Trent and Severn.

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[1] *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, Pl. X.

[2] Reports on the Water Supplies . . . in the Pershore Rural District, *op. cit.*, p. 25.

[3] Useful papers in connection with the geology of this district are those by Prof. W. S. Boulton, *Geol. Mag.*, 1928, pp. 255–266, 318–325.

Grafton Flyford.—Maps : 199, 200 ; 54 S.W. ; 29 S.E., 30 S.W., 34 N.E., 35 N.W.

This parish is on Lower Lias, with Drift of sparsely-distributed quartzite pebbles. It is dependent on wells [1]—especially on one in the allotments. The water is often brackish and of poor quality owing to surface water getting in. Boring would be practically useless : only a limited quantity would be obtained and that probably saline. Shortage is experienced at times in the parish.

Grafton Manor.—Maps : 182 ; 54 N.W. ; 15 S.E., 22 N.E.

This parish of scattered farm-houses is for the most part on Keuper Marl ; but this is faulted against the Lower Keuper Sandstone which floors a small tract at Hill Top.

A few houses are supplied by the East Worcestershire W. Co., but the majority by wells. The well at East Lodge Farm is 90 ft. deep.

Great Comberton.—Maps : 199, 200 ; 44 ; 48 N.E., S.E.

By far the greater part of the parish is on Lower Lias. A very small portion extends southwards to the summit of Bredon Hill in which crop out Middle Lias (Sandy Beds succeeded by Marlstone), Upper Lias clay, and Inferior Oolite.

The village is dependent on wells, and on a private undertaking (Major R. Handford) derived from several springs issuing from the base of the Sandy Beds and from slipped portions of those beds, about ¾ mile S.E. by S. of the church. The water gravitates from the tanks (about 500 gallons each) into another (about 200 gallons) and thence to the village in which it is laid on to the houses. It is understood that the pipes lead first to the lower part of the village, so that when the supply runs low the upper part is inadequately provided for. Greater storage provision would probably improve the position.

The outlying parts of the parish are dependent on wells.

Great and Little Hampton.—Maps : 200 ; 44, 54 S.W. ; 42 S.W., S.E., 49 N.W., N.E.

On Lower Lias clay, with local deposits of gravel, and down by the river Alluvium.

The parish is now served by the Evesham and Pebworth Joint undertaking, water being laid on to practically all the houses. It was previously dependent on wells and a small village-supply at Great Hampton. This ' old ' village supply, still available as an auxiliary, comes from springs issuing from gravel resting on the clay at Clark's Hill—just under half a mile north by east of The Spa. The water runs into a reservoir (15,000 to 20,000 gallons) from which it is piped to a hydrant near the School.

Salt waters have long been known to occur at Great Hampton.

HAMPTON SPA

Hampton Spa is situated on the north side of the Pershore road,[2] about 200 yds. west of Bengeworth Station, or three quarters of a mile west-south-west of the Bell Tower, Evesham. It is on the Lower Lias, and the mineral water is pumped up from a well, 41 ft. deep, in this formation.

The presence of saline waters in Hampton was known in William the Conqueror's time, if not earlier, for in Domesday Book it is recorded :—" The same Urso holds Hantune. Robert holds it of Urso. In demesne . . . a salt work rendering three orae." [3]

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[1] A well at Ennick Ford is 18 ft. deep (in the *Angulata*-Zone). *Trans. Worcs. Nat. Club*, vol. iii, p. 199.

[2] No. 38 Pershore Road.

[3] See ' A Literal Extension of the Latin Text ; and an English Translation of Domesday Book in relation to the County of Worcester.' Worcester and London, 1864, p. 49. Mr. St. Clair Baddeley, F.S.A., informs me that :—" The ' ora ' was a Danish reckoning of 20d. a piece and was a survival of Canute's days and customs. Three orae=5s. But there was no coin used of this name. It was only a computation that remained convenient."

George May in his ' History of Evesham ' (1834, pp. 13–14. Evesham and London. 2nd. ed., 1845) says :—" But amid the advantages attending its peculiar and beautiful situation, we must not, in the present day, omit the mention of these Saline and Mineral Springs which have during the last few years more particularly attracted public attention. Although in the parish of Hampton, adjoining Evesham at the south-west, springs of this character appear to have been very anciently known : for wells in that parish have been for many years disused, as unfit for ordinary purposes. In 1821 this subject became investigated, and after a public meeting in the town a committee was appointed, under whose direction wells were sunk, and a most copious saline spring was found, which on being subjected to analysis by Mr. Hume, in November, 1821, yielded the contents detailed beneath [on p. 181, No. 659].[1] And although from the extreme wetness of that season the water must necessarily have deteriorated, yet it will be seen from thence that the Hampton spring exceeds the Pure Saline Spring at Cheltenham in medicinal salts ; with the further advantage of containing considerably less chloride of sodium or common salt.

" Since the above analysis a neat pump-room and bath have been erected on the spot, which is most rurally and delightfully seated on the Avon. . . ." ‖

For some reason, however, no further action was taken, the land beneath which the spring existed changed hands, and at a later date the well was filled in.

In 1920 the land again changed hands, the well was re-opened, and a wooden hut—the present pump-room—was erected.

The " neat pump-room and bath " mentioned by May in his ' History of Evesham ' have disappeared, and all that can be said is that " old inhabitants seem to think that the present Spa is on the same site as that mentioned by May, and that a summer house indicates the place where the pump room stood."

This water contains more mineral matter than that of the now disused Royal Victoria of Bishopston Spa, one mile north-west of the Great Western Railway Station, Stratford-on-Avon. The SO_3 is distinctly higher, and is probably present as sulphate of soda ; this would be quite good for the liver.

Great Witley.—Maps : 182 ; 55 N.E. ; 20 N.E., S.E., 21 S.W., 27 N.E.

This parish embraces both low ground, formed of Lower Keuper Sandstone (on which are the village and Witley Court) succeeded by Keuper Marl (western portion of Witley Park), and high ground on the west and north, composed of Silurian rocks, overlain unconformably (at Woodbury Hill and north of the Hundred House) by Trappoid Breccia, and faulted against the Keuper. It is dependent on wells and springs—some of the latter being piped to supply houses.

Witley Court has a piped supply from a spring, about a mile to the west, which originates on the main line of fault. The ' Engine House ' in the Park, not now in work, was used to pump water for the ornamental fountain in the ' Italian Gardens.'

The Rectory and Whitehouse have a piped supply from a spring near the southern foot of Abberley Hill, while the Rectory obtains its drinking water from a strong spring—otherwise running to waste—in the garden a little to the south-west of the house. Wickham King informs me that both these springs come along a N.N.W. to S.S.E. fault and emerge in the Lower Keuper Sandstone.

Hundred House inn, houses adjoining the Post Office, and the doctor's house have a piped supply from a spring on the main line of fault which runs from Wallsgrove Quarry south-south-eastwards to the east side of Woodbury Hill.

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[1] For a more recent analysis, see No. 265 below.

‖ An account, very much the same as May's, is given by Dr. C. Hastings ' Illustrations of the Natural History of Worcestershire,' 1834, pp. 117–118.

Grimley.—Maps : 182 ; 55 S.E. ; 28 N.W., S.W.

Mostly on Keuper Marl, but around Northington the Lower Keuper Sandstone rises from beneath the Marl. Locally there are deposits of gravel and sand—worked in pits.

The parish is dependent on wells. Thorngrove has water from the Grimley Brook raised to it by ram for purposes other than drinking.

Guarlford.—Maps : 199 ; 55 S.E. ; 40 N.W., S.W., S.E.

On Keuper Marl, with local gravel.

The western portion of the parish, adjacent to the Malvern Urban District, is residential and some 70 houses have the U.D.C. water laid on. The remaining portion is dependent on wells, averaging about 20 ft. deep ; supplies are adequate, but mostly polluted. The shallow well at Stone Cottages (1 $\frac{5}{16}$ mile S.S.E. of Madresfield Court) is in gravel.

Portock's End.—A recent well in the Keuper Marl here, is 111 ft. deep (surface level, 119 ft. O.D.), and—when visited—had 42 ft. of water. A windpump raises the water to Portock's End and Dripshill House.

Hadzor.—Maps : 182 ; 54 N.W., S.W. ; 29 N.W., N.E.

Hadzor parish, including the village, is on Keuper Marl, except for a small south-easterly prolongation, between Goosehill Green and the Dean Brook, which is on Lower Lias, faulted down against the Marl.

Hadzor House, and two others, have the East Worcestershire Company's water laid on, but otherwise the parish is dependent on wells, the water in which is said to be adequate in quantity and of satisfactory quality.

Hagley.—Maps : 167 ; 54 N.W., 62 S.W. ; 4 S.E., 9 N.W., N.E.

From north-east to south-west the formations occuring at the surface are:—Coal Measures, Trappoid Breccia, Bunter Pebble Beds (then a fault), Lower Keuper Sandstone and Upper Mottled Sandstone. In Wassel Grove Pit, 29 ft. of fossiliferous Old Red Sandstone (Downtonian) were proved beneath 758 ft. 1 in. of Coal Measures (information from Wickham King).[1]

Practically the whole of the parish—including Hagley Hall, Blakedown, and Stackenbridge—has the Stourbridge and District W.B. water laid on.

'Jacob's Well,' in Hagley Park, is, Wickham King informs me, in Keele Beds[2] (Upper Coal Measures).

Halesowen.—Maps : 168 ; 62 S.W. ; 5 S.W.

A small parish on Coal Measures (sandstones of the Halesowen Group, with Etruria Marl rising from beneath them on the north-east boundary).

The town of Halesowen, lying in a hollow, is for the most part supplied by the South Staffordshire W. Co. ; but there are a number of private wells still in use both near and away from the Company's mains, and some rain-water cisterns. The water being unsatisfactory, the wells are gradually being replaced by Company's water. A public pump at Spring Hill was dismantled in 1907 after an outbreak of enteric fever. Another, opposite the foot of Bundle Hill, on the east side of Love Lane, stands over a shallow well which intercepts a perennial spring. This pump was repaired in 1923 to serve as a stand-by for houses around in times of drought.

Hampton Lovett.—Maps : 182 ; 54 N.W. ; 21 N.E., S.E., 22 N.W., S.W., 29 N.W.

On Keuper Marl with local traces of surface gravel (Drift). The parish is dependent on wells the water in which is said to be sufficient and good.

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[1] See also *Geol. Mag.*, 1912, p. 438, and 'The Southern Part of the South Staffordshire Coalfield' (*Mem. Geol. Surv.*), 1927, p. 22, and Vertical Sections, (*Geol. Surv.*) Sheet 94).

[2] The beds here are regarded by T. H. Whitehead as Enville Beds. See 'The Southern Part of the South Staffordshire Coalfield', *op. cit.*, p. 142.

Hanbury.—Maps : 182, 183, 200 ; 54 N.W., S.W. ; 22 S.W., S.E., 23 S.W., 29 N.W., N.E., S.E., 30 N.W,. S.W.

This is a large parish—7,790 acres. The eastern part between Fosters Green and Earls Common, in which is Broughton Green, is on Lower Lias : the western, including Hanbury, The Square, Mere Hall and Mere Green, on the underlying Keuper Marl.

The parish is dependent mostly on wells said, on the whole, to be satisfactory—in places pond-water is used, but it is of doubtful quality. Some wells near the canal are too saline, and neighbours resort to the well at the ' Eagle and Sun ' Inn.

Hanley Castle.—Maps : 199 ; 43 N.E., 44, 54 S.W., 55 S.E. ; 40 S.W., S.E., 47 N.W., N.E.

On Keuper Marl with local gravel. Hanley Castle is on the Marl ; Hanley Swan on gravel. The parish is dependent on wells, the supplies being generally adequate, but in places polluted. The wells in the gravel at Hanley Swan are shallow.

Hanley Swan has a sewerage scheme. At certain blind ends are flushing tanks which are filled with water from wells raised by means of a movable pump.

At Blackmore Park House, H. Tayleur informs me, the water is pumped from a well by an oil engine and there is a subsidiary supply from a ram, of brook water, but this latter has not been used of late.

Hanley Child.—Maps : 181 ; 55 N.E. ; 19 S.W., S.E.

This parish, on the Old Red Sandstone, is dependent on wells mostly fitted with pumps. The Birch Hill Limestone crops out west of the village, and on Broad Heath wells in the beds above this, largely sandstones, tap good supplies at 14 or 15 ft. down, although some of the better wells go down to 20 to 25 ft.

Hanley William.—Maps : 181, 182 ; 55 N.E. ; 19 N.E., S.E., 20 N.W., S.W.

This parish is for the most part on Old Red sandstones, lying above ' The Limestone ' (Birch Hill Limestone) which crops out to the north.

According to H. Tayleur, Agent to the Hanley Court Estate, there is in a general way a plentiful water supply from the banks beginning near the New Road to Nashfield Coppice : Wall Hill, above Mr. Meredith's house seems almost barren of water and in the bank above Ferneyhill there is only one weak spring. The springs in Hanley Dingle are drained by a small brook and this supply is of some importance.

Hanley Court, supplied by gravitation from a spring near Church Farm, has a reserve tank of brick and concrete to hold 12,000 gallons.

Broomy Fields Farm is supplied from a fairly strong spring on Church Farm. Collected into a brick tank and piped to a second tank about half a mile distant (to obtain a head) the water gravitates to the farm and Brick Barn's Cottage. Hanley Mill is supplied by gravitation from a spring collected into a brick tank 250 yds. from the house ; Hanley New Road Cottages, from a s trong spring, collected in a brick tank situate in a field some 150 yds. distant.

Hartlebury.—Maps : 182 ; 55 N.E., 54 N.W. ; 14 S.W., S.E., 21 N.W., N.E.

The village and most of the parish are on Lower Keuper Sandstone. To westward, Upper Mottled Sandstone crops out from beneath it—the junction being well exposed in the road-cutting at Titton—and on it Summerfield and Wilden are situate. Keuper Marl succeeds the Lower Keuper Sandstone east and south of Hartlebury Station. Locally, as on the Common, sand and gravel occur.

Two houses have Kidderminster Town water laid on, but otherwise the parish is dependent on wells.

In the School field of Queen Elizabeth's Grammar School (about 340 ft. above O.D.) there is a borehole 105 ft. deep at the bottom of a well (5 ft. deep), the whole in Lower Keuper Sandstone. The supply, raised by windpump, is good—not deficient in the drought of 1921.

Harvington.—Maps : 200 ; 54 S.W., S.E. ; 35 S.E., 42 N.E., S.E., 43 N.W.

Roughly speaking, the portion of the parish east of the village is on Keuper Marl ; the rest on Lower Lias. In the Marl the Arden Sandstone is developed : the southern part of the village is built on it and the northern part on the immediately overlying marls.

The village was formerly dependent on wells, mostly deep, sunk either direct or through a covering of marl into the Arden Sandstone. The water became badly contaminated in many of the wells, and now the village is supplied by the Evesham and Pebworth Joint Water Committee.

Hasbury.—Maps : 167, 168 ; 54 N.W., 62 S.W. ; 4 S.E., 9 N.E.

Hasbury parish is on Upper Coal Measures (marls and sandstones of the Halesowen Beds).

Some 569 out of the 716 houses are served by the South Staffordshire Waterworks Company.

A lamp-post, formerly a public pump, marks the site of " Wall Well," a spring earlier flowing from an arched recess and reached by inclines on each side. The site is on Halesowen Sandstone.

" St. Margaret's Well " is in the private grounds of a house recently erected, and is a spring issuing from the Halesowen Sandstone at the junction of two faults (shown west of the ' H ' of Hasbury on the new series Geological Map, Sheet 168) about 100 yds. S.W. of the point where Blackberry Lane joins Hagley Road. It is referred to, as a well of good cold unmineralised water, by T. Nash in 1781.[1] A well at 304 Hagley Road, 60 ft. deep and 32 ft. to water, supplies two houses and in times of drought a number in the vicinity.

Hill and Cakemore.—Maps : 168 ; 62 S.W. ; 4 S.E., 5 N.W., S.W.

On Upper Coal Measures (clays of Halesowen Beds, and Etruria Marl) and a small area of Middle Coal Measures, with stony clay (Drift) on the high ground around Cockshot.

Some 1,042 houses out of some 1,823 are served by the South Staffordshire W. Co. The remainder are dependent on wells. The quantity in these is, on the whole, adequate, but many ran dry in the drought of 1921.

An uncovered well at the corner of Spies Lane, Victoria Avenue, is 8 ft. deep and 5 ft. 3 in. to water, which is adequate and good. The subsoil water in the vicinity occurs at an average depth of 6 ft. Recent excavations to lay a new sewer in Victoria Avenue showed the presence of ' running sand ' [Drift].[2]

Hill Croome.—Maps : 199 ; 44 ; 47 N.E., 48 N.W., S.W.

This parish is for the most part on Keuper Marl. In the steep bank which runs north and south across the eastern portion of the parish crop out the topmost beds of the marl, the Rhaetic, and basement beds of the Lower Lias. The parish is dependent on wells.

Hill and Moor.—Maps : 200 ; 54 S.W. ; 41 N.E., 42 N.W., S.W.

The eastern extremity of this parish, known as " Hill Furze," is on the red Keuper Marl ; but the rest is on Lower Lias on the surface of which (as at Moor) are local deposits of sand and gravel—part of a river terrace (see Fladbury, p. 54), and, alongside the Avon, Alluvium.

Hill is on blue Lower Lias clay. Dr. G. H. Fosbroke states [3] that two

[1] ' History of Worcestershire,' vol. i, 1781, p. 528. For a detailed description see L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), pp. 143, 144.

[2] Particulars communicated by J. W. Cox, Sanitary Inspector.

[3] Reports on the Water Supplies . . . Pershore Dural District, *op. cit.*, pp. 46, 47.

wells furnish the supply of drinking water. The water in one well, however, is a mineralised water and in the other unfit for the purpose. There are indeed other wells, but the water there is too brackish—in one of them " you cannot even wash your hands in it."

Of well-water samples examined on a certain occasion only 19.0% were reported ' fit for drinking purposes.'

Upper and Lower Moor are on sand and gravel of a river terrace.[1] In Lower Moor abundant water is met with at about 11 to 12 ft. down : the well at the cottage at the turning from the Springhill road to Lower Moor is 9½ ft. deep and had in it when examined 3 ft. of water.

Hillhampton.—Maps : 182 ; 55 N.E. ; 20 N.E., S.E., 21 N.W., S.W.

Hillhampton parish is a furrowed tract of Lower Keuper Sandstone. The comparatively few scattered houses are dependent on wells—fairly deep.

Himbleton.—Maps : 182, 183, 199, 200 ; 54 S.W. ; 29 (4 qrs.)

This parish is mainly on Lower Lias, with limestone-beds formerly worked in a number of quarries. Very small tracts near Shernal Green are on Keuper Marl. In places there are traces of quartzose sand and gravel (pebbles from the Bunter Pebble Beds) on the surface of the Lias, and down by the Bow Brook, under the greater part of the village, similar gravel apparently forms part of a little river-terrace.[2] The parish is dependent on wells the supplies from which are of fair quantity and quality.

Hindlip.—Maps : 182, 199 ; 54 S.W. ; 28 S.E., 29 S.W.

On Keuper Marl, in which the Arden Sandstone crops out near Offerton Farm. Locally, there is a sprinkling of quartzite pebbles (Drift).

The parish is dependent on wells, mostly shallow, and there has been no complaint of shortage.

Hindlip Hall.—A spring issuing near the Arden Sandstone at Offerton Farm is caught there in a well and piped down the meadows to a spot, between the farm and Hall, where a pair of rams, a wind-pump and an oil engine force up the water to the Hall for the supply of the house, farm and pastures. There is a good overflow into a ditch by the roadside.

Holdfast.—Maps : 216 ; 43 N.E., 44 ; 47 S.E., 54 N.E.

The low ground of this parish is on Keuper Marl, with local gravel. The hill ground is on part of an outlier of Rhaetic with basal Lower Lias limestones and clays.

The parish is dependent on wells. The water of a small spring issuing from the Lower Lias some 250 yds. north-west of Holdfast Hall is very hard—total hardness 165° ; permanent hardness, 105°.

Holt.—Maps : 182 ; 55 N.E., S.E. ; 21 S.W., S.E., 28 N.W., N.E.

Holt parish is for the most part on the Lower Keuper Sandstone ; but in places around its margin—as beneath Ockeridge Wood—occurs the overlying Keuper Marl. Local gravel. The parish is dependent on wells : those at the Police Station, Schools and Council Cottages are over 90 ft. in depth.

Huddington.—Maps : 182, 199 ; 54 S.W. ; 29 S.E., S.W., 34 N.W.

On the Lower Lias clays with limestones which have been quarried to a small extent in the past. The parish is dependent on wells.

Hunnington.—Maps : 168 ; 54 N.W., 62 S.W. ; 5 S.W., 9 N.E., 10 N.W.

On faulted clays, marls and sandstones of the Upper Coal Measures (Halesowen, Keele and Enville Beds).

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[1] Tomlinson, M.E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, Pl. X.

[2] *Bos longifrons* and fresh water shells have been found (*Trans. Worcs. Nat. Club*, vol. for 1847–96, 1897, pp. 47, 97) ; also, from " gravel at Himbleton, being probably derived from the Kimmeridge Clay," part of a *Cimoliosaurus* (Cat. Fossil Rept. and Amphibia, Brit. Museum, pt. 2, 1889, p. 203).

The majority of the houses are supplied from the South Staffordshire W. Co. main, which crosses the parish. There are very few wells : the water in such as there are, is said to be satisfactory both as regards sufficiency and quality.

Illey. –Maps : 168 ; 54 N.W., 62 S.W. ; 5 S.W., 10 N.W.

Illey parish is on Halesowen and Keele Beds (Upper Coal Measures). Some 5 out of 31 houses in the parish have water laid on from the Birmingham Waterworks : the others are dependent on wells.

Inkberrow.—Maps : 183, 200 ; 54 S.W. ; 30 (4 qrs.), 35 N.W., N.E.

A large parish, for the most part on Keuper Marl (with Arden Sandstone) with local deposits of sand and gravel, especially near the Ridgeway on the eastern boundary. The smaller portion west of Inkberrow Comb and Morton Underhill is on the Lower Lias.

Inkberrow village is dependent on wells from 20 to 40 ft. deep in the Arden Sandstone on which it is mostly built. The water is of good quality, though liable to local pollution, and does not fail even in dry summers. In the marl, on the other hand, at Holberrow Green, where the average depth of the wells is 20 ft., the supply does not always hold out. At Cookhill village, built chiefly on the Ridgeway, the wells are much deeper—up to 100 ft. or more. At Stockwood, on the Lower Lias, J. Farmer informs me that the water in the wells is saline—a common occurrence in this formation—and none is used for drinking purposes.

Kempsey.—Maps : 199 ; 54 S.W. ; 33 S.E., 40 N.E., S.E., 41 N.W.

On Keuper Marl, with local sand and gravel—as under Kempsey village and Kerswell Green. Flood-water rises up the valley of the Hatfield Brook in Kempsey village to 46 or 47 ft. above O.D.

Some 30 houses are supplied from the Worcester City Waterworks ; but otherwise the parish is dependent on wells, the supplies in which are adequate though mostly contaminated. The waters of the wells in the sand-bed under Kempsey village vary considerably in hardness : a sample from the Crown Inn was exceptionally hard (analysis, No. 332).

A boring at The Nash, by Messrs. Le Grand, Sutcliff & Gell, Ltd., in 1927, got :—Soil, etc., 4 ft. ; blue, red and mottled marl to 14 ft., red marl to 120 ft., do. with gypsum and ' conglomerate ' to 150 ft. (bottom). Water was found near the surface, at 120 ft., and at 127 ft., but was unfit for use. Rest-level, 3 ft. Yield, 720 gallons per hour. Boring abandoned.

Kenswick.—Maps : 182, 199 ; 55 S.E. ; 28 S.W.

This parish is on Keuper Marl, and is dependent on wells—not deep. Kenswick Manor has, in addition, a non-potable supply raised by ram from the brook.

Kidderminster Foreign.—Maps : 167, 182 ; 54 N.W., 55 N.E. ; 7 N.E., S.E., 8 N.W., S.W., S.E., 9 S.W., 14 N.W., N.E., S.W.

This is a large parish (5,877 acres) which surrounds Kidderminster Borough except for a short stretch on the north.

The north-eastern portion is on Palaeozoic rocks—a distorted anticline of Lower Old Red Sandstone (on which are Trimpley and Park Attwood), with Coal Measures to the north-west (Eymore Wood) and again in a very narrow strip to the south-east, where they are succeeded by Trappoid Breccia. Then comes a fault, to the east of which are Triassic rocks. These are the Lower Mottled Sandstone (Habberley Valley), Pebble Beds (Low and High Habberley and Puxton), and Upper Mottled Sandstone. This last formation is faulted against the Pebble Beds south of Kidderminster and floors the remainder of the parish to the east.

Sutton Park (the residential portion of the parish adjacent to Kidderminster Borough), houses in Oldingham, and The Fountain Inn, (Habberley Valley) have Kidderminster water laid on : a number of houses on the Holbeache and Park Attwood Estates are supplied from the Elan Aqueduct of the Birmingham Corporation ; but the other houses are dependent on wells and springs.

There are many springs in the Trimpley district issuing from the Lower Old Red Sandstone. Locally the water is very hard and the brook west of Bannering's Cottage, N.W. of Trimpley, at a small cascade has formed a conical mass of calcareous tufa, 3 or 4 ft. high.[1]

A good spring coming from Pigstyehill Coppice on the western side of the Habberley Valley is caught in a large brick chamber and piped to some large houses, such as Rock House, Habberley House, and High Habberley House, in the neighbourhood. For about two-thirds of the year there is a good overflow which is piped into the valley to a ' spout ' where water is obtained by cottagers in the vicinity. Some of this surplus water might be stored in a reservoir against dry periods.

In Honey Bottom brook-water is used : the quality is good except when occasionally polluted by cattle.

BORING AT THE WOODLANDS, HABBERLEY VALLEY

Made in December, 1908.

			Thickness Ft.	Depth Ft.
	Shaft (diameter, 3 ft. 6 in.) :			
? Base of Pebble Beds and Lower Mottled Sandstone	1.	Red sandstone	185	185
	Borehole (diameter, 6 in.) :			
Lower Mottled Sandstone	2.	Red sandstone	72	257
	3.	Marl	36	293
	4.	Sandstone	37	330

Rest-level.—169 ft. ex surface. Yield.—400 gallons per hour (capacity of pump) ; possible yield believed to be much in excess of this. Supplies " The Woodlands." The shaft had been put down some considerable time previous to the bore and yielded little water.

Kington.—Maps : 200 ; 54 S.W. ; 30 S.W., 35 N.W.

This parish on the Lower Lias is dependent on shallow wells, the water in some of which is saline and of poor quality ; and there is, locally, occasional shortage.

Knighton-on-Teme.—Maps : 181 ; 55 N.E. ; 12 S.W., S.E., 19 N.W., N.E.

This parish is on Old Red beds—principally the marls below the Downtonian or Birch Hill Limestone. Locally, as near The Waddings, there are patches of gravel on the surface and, down by the River Teme, alluvium.

The parish is dependent on wells. Newnham Court and farm-buildings, Whitehouse, the Hole Cottages and buildings and several drinking troughs in fields, are supplied from a reservoir on The Mount to which water is raised from the River Rea by pumps operated by a water-wheel at Newnham Mill.

Knightwick.—Maps : 199 ; 55 S.E. ; 32 N.W., N.E.

Knightwick parish and village are mainly on the Old Red Sandstone, the Silurian rising up from beneath in the east of the parish. The parish is dependent on wells ; but a house near Knightsford Bridge has a piped supply

[1] Cantrill, T.C., ' Geology of Wyre Forest,' 1895, p. 32.

from the dip well at Black's Well hamlet, and Knightwick Manor has brook water raised by ram.

Between Knightsford Bridge and the village a number of small springs break out of the bank on the left ; while on the right a good spring originates in the hollow and gives rise to the streamlet that enters the River Teme near Knightsford Bridge.

(For Knightwick Sanatorium see Doddenham parish).

Kyre Magna.—Maps : 181 ; 55 (4 qrs.) ; 19 S.W., S.E., 26 N.W.

Kyre or Wyward Magna parish stretches across the valley of the Kyre Brook over a slightly flexed anticline of Old Red beds—principally marls—below the horizon of the Birch Hill Limestone, which crops out in the extreme north-west in Woodbank Hill and in the extreme south-west at Garmsley.

The parish is dependent on wells ; but Kyre House has a gravitation supply from a spring issuing from this Limestone east of Garmsley.

Kyre Parva.—Maps : 181 ; 55 N.E., S.E. ; 19 S.E., 26 N.E.

This parish is on Old Red beds—principally marls (with local surface deposits of gravel by the Kyre Brook) below the horizon of the Birch Hill Limestone—in the valley of the Kyre Brook. It is dependent on wells.

Lapal.—Maps : 168 ; 62 S.W. ; 5 S.W., 10 N.W.

On Upper Coal Measures (mostly Halesowen Beds and Etruria Marl) with stony drift capping the high ground along Carter's Lane.

At Manor Pit, 1,200 yds. E. of Halesowen Church, the base of the Coal Measures was reached at 1,202 ft. down, resting on the following fossiliferous Downtonian strata [1] (as communicated to the author by W. Wickham King) :—

	Ft.	In.
Red rock	7	0
Red mottled ground	21	6
White gritty rock	0	6
Red mottled ground	5	6
do. (bored in)	48	0
	82	6

Lapal Farm has water laid on from a pool higher up the hill, but otherwise the parish is dependent on wells.

Leigh.—Maps : 199 ; 55 S.E. ; 32 N.E., S.E., 33 N.W., S.W., 39 N.E., 40 N.W.

Leigh is a large parish (4,941 acres) on Keuper Marl, locally covered by sand and gravel, with alluvial meadow-land down by the River Teme. The steep bank of Marl overlooking the Alluvium is deeply furrowed by such streams as the Leigh Brook and that which flows down Hayley Dingle ; locally, springs issue from the bank top, e.g., ' Cattern's Well,' [2] near Leigh. About 1 mile S.S.E. of Leigh Sinton boreholes at the Malvern Link Gas Works (p. 125) proved 705 ft. of the Marl above the Lower Keuper Sandstone ; but near the western extremity of the parish the Marl decreases in thickness and the Sandstone rises to the surface from beneath it to the west of Upper Sandlin. Water obtained from the Sandstone by means of boreholes through the Marl is often found to be too hard for ordinary domestic purposes.

[1] For further details see *Geol. Mag.*, 1912, pp. 438, 439 ; *Proc. Birm. Phil. Soc.*, vol 5, p. 138 ; ' Geology of Southern Part of S. Staffs. Coalfield ' (*Mem. Geol. Surv.*), 1927, p. 22. Plate xiii, etc. ; and No. 6 on Vertical Section Sheet 94 (*Geol. Surv.*), (in the press).

[2] See L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), pp. 144, 145.

The parish is dependent on wells, some fitted with pumps ; but at The Brooklands, Leigh, and Hopton Court non-potable water from Leigh Brook is forced up by rams. A few small springs issue from the sand and gravel, as at Coles Green. (See also Madresfield).

BORING AT UPPER SANDLIN

Completed (14th Feb., 1882) and particulars communicated by Messrs. LeGrand, Sutcliff and Gell, Ltd., Southall. Surface-level 199.8 ft. above O.D.

			Thickness. Ft.	In.	Depth. Ft.	In.
[Keuper Marl]	1.	Blue marl and red sandstone	9	0	9	0
	2.	Red sandy marl	6	0	15	0
	3.	Red and blue stone, marl and sandstone	6	0	21	0
	4.	Red and blue marl	18	6	39	6
	5.	Red marl	11	6	51	0
	6.	Red and blue marl	9	6	60	6
	7.	Red marl	20	6	81	0
	8.	Red and blue marl	5	6	86	6
	9.	Red marl	21	0	107	6
	10.	Red and blue marl	3	0	110	6

Tubing.—25 ft. of 3-in. pipe remaining in borehole. Water-level.—6 ft. 6 in. below surface. Yield.—450 gallons per hour.

Lindridge.—Maps : 181, 182 ; 55 N.E. ; 12 S.E., 13 S.W., 19 N.E., 20 N.W.

A Temeside parish, mostly on Old Red beds below the Birch Hill Limestone horizon—principally marls, and all with southerly dip. On these, at Frith Common and Menith Wood, Coal Measures (probably Upper) rest unconformably. Springs at both these places supply a considerable number of neighbouring cottages ; while from another near Frith Common water is piped to a reservoir whence some thirteen houses on the Worcester Road at Eardiston are supplied.[1]

Whitehouse Farm, ' Eardiston Stables ' and gardens, and cattle-troughs are supplied by ram from the River Teme below Meadows Mill weir through a reservoir on the hill a quarter of a mile N.N.E. of Whitehouse. Similarly, Dumbleton Farm and ' Woodlands ' have non-potable water forced up by a ram in Dumbleton Brook below the bridge at Dumbleton.

Little Comberton.—Maps : 200 ; 44, 54 S.W. ; 41 S.E., 42 S.W., 48 N.E., 49 N.W.

On Lower Lias. Traces of gravel.

The village owes its supply to a scheme, supported by Mr. Thackwell some thirty years ago, the upkeep of which is provided for by more or less graded contributions. The source consists of two springs, issuing at or near the base of the Sandy Beds of the Middle Lias and slipped portions of those beds, about ¾ mile S. by E. of the church. The water is run into a reservoir (30,000 gallons capacity) a little distance away, and gravitates to the village, in which it is laid on to one or two houses and stand-posts. With care, the supply is adequate.

The village is mostly on Lower Lias clay : there is a vein of gravel at the vicarage in which there is a well yielding good water. But many of the other wells yield saline water.

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[1] Wickham King writes me that the chief springs at Frith are along a N.–S. fault. Menith Wood wells are in Coal Measures. On the south side of that wood and at Frith Common are springs that arise along the boundary between the coarse conglomerate at the base of the Coal Measures and the Downtonian.

Little Malvern.—Maps : 199, 216 ; 43 N.E. ; 46 N.E., S.E., 47 N.W., S.W.

The hill portion of this parish is on Archaean : the low ground on Keuper Marl, locally covered by gravel.

The Malvern U.D.C. supply is available for parish residents, at a price about double the amount charged within the Urban District. Some three or four establishments have this water laid on : other residents generally depend upon supplies from shallow wells.

A spring issues from the valley on the south side of the Camp reservoir, but being right away from any dwelling and at a comparatively low level runs to waste.

Little Witley.—Maps : 182 ; 55 N.E., S.E. ; 20 S.E., 21 S.W., 27 N.E., 28 N.W.

Roughly speaking, the village and northern portion of the parish are on Lower Keuper Sandstone ; the southern, on the succeeding Keuper Marl. The parish is dependent on wells.

Longdon.—Maps : 216 ; 43 N.E., 44 ; 47 S.W., S.E., 54 (4 qrs.).

A considerable parish on Keuper Marl, including the Arden Sandstone.

Village and parish are dependent on wells the supplies in which are adequate, but in many cases polluted. The village is on the Arden Sandstone. The well at Longdon Hill End (now ' Hillend Dairy Farm ') is 65 ft. deep.

Lower Sapey.—Maps : 182 ; 55 N.E., S.E. ; 20 S.W., 26 N.E., 27 N.W.

On Old Red Sandstone—beds above the Birch Hill Limestone.

The parish is dependent on wells from 30 to 70 ft. deep. Formerly there were two grist mills on the Sapey, locally called the ' Holloway ' Brook, near the source of the Clifton-on-Teme supply (see p. 46).

Lulsley.—Maps : 199 ; 55 S.E. ; 32 N.E.

The greater part is on Keuper Marl, separated by a fault from a small tract in the west—near Knightwick Station—in which a variety of rocks, namely, Silurian, Old Red Sandstone, Trappoid Breccia (at Osebury Rock), Upper Mottled Sandstone, Lower Keuper Sandstone and Keuper Basement Beds (breccia and sandstone) occur. Prof. T. T. Groom has mapped this tract in detail.[1]

The parish is adequately supplied by wells.

Black's ' Well.'—This is a useful spring, marked on the six-inch map, that ' boils up ' from the Upper Mottled Sandstone on the right hand side of the road from Knightwick Station to Knightsford Bridge. The water runs along the road-side for a short distance, then under the road down a hollow and close by a dip well. This, which the cottagers wrongly call Black's Well, is about 3 ft. deep and has a lid ; fed by a running spring, its water-level has not been known to fall and the overflow runs into the stream from Black's Well proper. A pipe also leads from the well to a house near Knightsford Bridge.

Useful springs originate from the faulted Silurian of Ravenshills Wood and give rise to the stream that flows down the deep Broad Dingle, cut in Keuper Marl, into the River Teme.

Lutley.—Maps : 167 ; 62 S.W. ; 4 S.E., 9 N.E.

Lutley parish is on the Coal Measures.

Some 19 out of the 36 houses have the South Staffordshire W. Co.'s water laid on : the remainder are dependent on wells.

Madresfield.—Maps : 199 ; 55 S.E. ; 40 N.W., N.E., S.W.

This parish is on Keuper Marl, with local traces of gravel. It is supplied

[1] *Quart. Journ. Geol. Soc.*, vol. lvi, 1900, fig. 28, p. 186.

partly by an undertaking belonging to Earl Beauchamp and partly by wells.

The source of Earl Beauchamp's undertaking is a distant spring (known as ' Cowleigh Spout ' ; analyses Nos. 371, 372) situated opposite the entrance to Cowleigh Park Farm at Malvern North End on the border of Leigh parish. It is on Wenlock Shale ground, but the bulk of the water drains from the hollow above the spring. The water is piped to a reservoir (30,000 gallons) at Woodsfield, Madresfield, from which it is laid on to the Court, School, four farms and a dozen houses. The average daily quantity obtained is 10,000 gallons, but there has always been plenty running to waste out of ' The Spout '—even in the drought of 1921. Near it (and within Leigh parish) is a large tap in a brick erection.

Before completion of this undertaking the chief supply for the village was from a well near the church, now condemned.

Mamble.—Maps : 182 ; 55 N.E. ; 12 N.E., S.E., 13 S.W.

The greater part of this parish is on Coal Measures [1] (with one working pit), resting on the ' Lower ' Old Red Sandstone, which crops out in the extreme western portion.

Village and parish are supplied by draw-wells and wells fitted with pumps. The supply is ' medium ' but does not absolutely fail. There is a public well at Clows Top in the Coal Measures (6 ft. deep ; 5 ft. of water, August, 1923) with a brick cover and pump. New House Farm has spring water forced up to it by ram.

Martin Hussingtree.—Maps : 182 ; 54 S.W. ; 28 N.E., S.E., 29 N.W., S.W.

On Keuper Marl with local superficial Drift (sand and gravel).

The parish is dependent on wells, mostly shallow, and there have not been any complaints of shortage.

Martley.—Maps : 182, 199 ; 55 N.E., S.E. ; 20 S.E., 27 N.E., S.E.

A considerable parish, spreading over rocks of various ages. The eastern portion (in which are Laugherne House, Willow Green, Newtown, Berrow Green, Martley village (east) and eastern part of Hill Side) is on the Keuper Marl, Berrow Green and The Noak being on the basement-beds just above the Lower Keuper Sandstone ; Berrow Farm and Martley village (west) are on the Sandstone. Then comes a fault, to the west of which are Silurian (Tinkers Copse, Hillend, and the western part of Hill Side), Old Red Sandstone (Horsham and Hill Top), traces of Coal Measures, Trappoid Breccia (Berrow Hill) and traces of Cambrian Quartzite and Archaean near Martley. [2] The eastern part of the parish is drained by the Laugherne Brook ; the western by the River Teme.

Wells in the Keuper Marl tract are from 15 to 60 ft. deep and yield an adequate supply, liable to local pollution. Those in the west of Martley village (Lower Keuper Sandstone) are from 30 to 90 ft. deep and yield a good supply of water, again liable to local pollution.

The Silurian tracts are dependent on rather shallow wells and springs. The Noak derives its supply from a well : Berrow Farm from a spring on the hill. Laugherne House is supplied by ram from Laugherne Brook, and for drinking purposes has a well.

There are useful springs running to waste at Hill Side in ' The Moors ' near the Church (" St. Peter's Well enough to supply the whole village ") ; and the springs on Berrow Hill could supply more than they do. ' The Hollins ' two farms have a piped supply from springs on the hill. The Rev. J. F. Hastings tells me that the parish is on the whole well supplied with springs at normal times, but several—especially those on the limestone at Hill Side—run dry in continued hot weather.

[1] 100–150 ft. thick in pits. (E. A. Newell Arber, *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, p. 410 ; T. C. Cantrill, ' Geology of Wyre Forest,' 1895).

[2] Groom, Prof. T. T., *Quart. Journ. Geol. Soc.*, vol. lvi, 1900, p. 163.

Naunton Beauchamp.—Maps : 199, 200 ; 54 S.W. ; 34 S.E., 35 N.W., S.W.

Except for local sand and gravel deposits, the parish and most of the village are on Lower Lias clay.

Both are dependent on shallow wells, the water in many of which is very salt, so that many of the villagers obtain their water from the Piddle Brook. Great shortage is generally experienced in dry periods ; the village was particularly badly off during the drought of 1921.

Naunton Court.—I am informed that a vein of sand runs under the Court and in it is a well containing excellent water. Many of the villagers fetch their water from here, though it is half a mile distant.

Netherton.—Maps : 200 ; 44 ; 49 N.W., S.W.

The greater part of the parish, including the little village, is on Lower Lias ; but in the east there is a small tract of Keuper Marl faulted up against the Lias.

The village has water laid on from the Elmley Castle supply.

North Claines.—Maps : 182, 199 ; 54 S.W., 55 S.E. ; 28 N.E., S.W., 29 S.W., 33 N.E., 34 N.W.

On Keuper Marl with the usual local spreads of gravel and sand. Fernhill Heath, a rapidly growing residential district for Worcester, is in this parish, and is supplied partly by Worcester City water and partly by wells.

North Hallow.—Maps : 182, 189 ; 55 S.E. ; 28 N.W., S.W., S.E., 33 N.W., N.E.

On Keuper Marl with local sand and gravel.

A few houses (' The Mount,' etc.) have Worcester City water laid on, but otherwise the parish is dependent on wells, a few of them fitted with wind-pumps. The well at the new Council Cottages, Worcester Road, is 14 ft. deep in sand (resting on the Marl), and water rests 8 ft. down ; the supply is sufficient and of good quality.

BORING AT PARKFIELD

Completed (30th July, 1904) and particulars communicated by Messrs. LeGrand, Sutcliff and Gell, Ltd., Southall. Surface-level.—140 ft. above O.D.

			Thickness		Depth	
			Ft.	In.	Ft.	In.
[Superficial Deposits]	1.	Top soil	3	0	3	0
	2.	Brown sand...	3	0	6	0
	3.	Coarse gravel	3	0	9	0
[Keuper Marl]	4.	Marl (a little water) ...	27	6	36	6
	5.	Grey rock and marl in bands	7	6	44	0
	6.	Red marl and bands of soft red marlstone	39	8	83	8
	7.	Blue rock	1	6	85	2
	8.	Red marl and bands of marlstone	25	4	110	6
	9.	Hard grey rock	1	0	111	6
	10.	Red marl and bands of marlstone	10	3	121	9
	11.	Hard grey rock	1	0	122	9
	12.	Marly clay and marlstone...	2	3	125	0
	13.	Marlstone and gypsum ...	4	6	129	6
	14.	Marlstone, grey sandstone and gypsum	9	6	139	0
	15.	Marlstone and gypsum ...	4	0	143	0
	16.	Marlstone, sandstone and thin layers of gypsum	7	0	150	0

Tubing remaining in borehole.—15 ft. of 4-in. pipe, top at surface. Water-levels.—Standing, 19 ft. 6 in. ex surface : pumping, 88 ft. 6 in. ex surface. Yield.—210 gallons per hour.

North and Middle Littleton.—Maps : 200 ; 54 S.E. ; 42 N.E., S.E., 43 N.W., S.W.

This parish is on Lower Lias, except on Cleeve Hill (the bank overlooking the Avon-side alluvium) in which the Rhaetic and topmost beds of the Keuper Marl crop out.

The villages are on the Lower Lias clay and water is laid on to the houses from the Evesham and Pebworth J.W. Com. supply.

North Piddle.—Maps : 199, 200 ; 54 S.W. ; 34 N.E., S.E., 35 N.W.

This parish is on the Lower Lias clay, with the usual results—brackish water, frequent surface contamination of the shallow wells, and local shortage in dry periods. This is the case in the village, where the wells are from 12 to 25 ft. deep.

Parts of the parish lie so low that drainage is difficult and portions of the roads are flooded after excessive rainfall.

North Redditch.—Maps : 183 ; 54 N.W. ; 23 N.W., N.E.

On Keuper Marl with sand and gravel drift.

The most populous part of the parish, adjacent to Redditch, is supplied by the East Worcs. W. Co. The scattered houses are mostly dependent on wells.

Norton and Lenchwick.—Maps : 200 ; 54 S.W., S.E. ; 42 (4 qrs.).

On Lower Lias clay with local deposits of sand and gravel.

There is a public supply for the village, now the property of the Rural District Council, but formerly owned by Sir Charles Swinfen Eady. Its source is in springs issuing from gravel and sand resting on clay between the Birmingham road and the railway, about a quarter of a mile E.S.E. of Norton Church. The water, collected in a chamber, is raised, by a ram when the flow is adequate and by a petrol engine when it is not, to a reservoir (14,000 to 15,000 gallons) and gravitates mostly to standposts, although it is laid on to a few houses, including two at the foot of Hipton Hill, which formerly obtained water from a small spring just above. A few houses still have wells.

The houses along the Worcester Road, as far as and including Woodnorton, have Evesham water laid on by an agreement with the Corporation, renewed for 12 years in 1923.

Lenchwick House is supplied from a spring in gravel resting on Lower Lias clay, forced up by ram.

Norton-Juxta-Kempsey.—Maps : 199 ; 54 S.W. ; 33 S.E., 34 S.W., 40 N.E., 41 N.W.

In the corner of the parish S.E. of Norton House is a tract of Lower Lias ; the rest is on Keuper Marl with surface deposits of gravel.

Worcester City water is laid along the road as far as Norton Barracks. Otherwise the parish is supplied, adequately, from wells—a number, as at Hatfield Norton and at Wood Hall, being fitted with windpumps. The wells at both these houses are about 80 ft. deep ; in that at Wood Hall the water stood on October 3rd., 1923, at 63 ft. below the surface, and the supply has never given out or run low.

Oddingley.—Maps : 182, 199 ; 54 S.W. ; 29 N.W., S.W., S.E.

Oddingley parish lies on the highest beds of the Keuper Marl and is supplied by wells ; some are very shallow, but the water is said to be sufficient and good.

Offenham.—Maps : 200 ; 44, 54 S.W., S.E. ; 42 N.E., S.E., 43 S.W., 50 N.W.

On Lower Lias largely covered by gravel (river terrace [1]) in the low-lying western portion of the parish—in which is the village. Bordering the River Avon is Alluvium.

The village has the Evesham and Pebworth Joint Supply.

Ombersley.—Maps : 182 ; 55 N.E., S.E., 54 N.W., S.W. ; 21 (4 qrs.), 28 N.E.

A large parish, most of it, including the village, on Lower Keuper Sandstone. Keuper Marl succeeds at Hadley Cross, Chatley Green and Hawford. Hadley Mill and the cottages in the vicinity are in broken country on the Sandstone against which, on the east, the marl is let down by a large fault running from Doverdale, *via* Hadley, in the direction of Salwarpe ; it is noticeable that the Elmley or ' Hadley ' Brook, as the part near Hadley is called, hugs the fault line. It is probable that when the water table in the Sandstone rises, springs ' boil up ' in Hadley Brook : certainly the valley where it is crossed by the Droitwich–Ombersley road soon floods extensively, and springs issue also near Turn Mill. These outbursts of water are located at the lowest levels of Keuper Sandstone exposed ; further downstream the sandstone has disappeared beneath the relatively impervious cover of the marl. Locally, there is gravel.

Village and parish are dependent on wells. At the cross-roads in the village the water-level is normally about 5 ft. down : wells on higher ground have to go deeper to reach it.

Near the Mill at Hadley is a useful spring, reached in a dip well, issuing from the Sandstone.

At Turn Mill the streamlet fed by springs issuing from the Sandstone has been impounded to work a mill (temporarily disused) by means of a water-wheel reported to be the largest in the Midlands. A disused and forgotten ' Holy Well ' seems once to have existed near Turn Mill.[2]

Orleton.—Maps : 182 ; 55 N.E. ; 20 N.W., S.W.

A Teme-side parish on Old Red beds below the horizon of the Birch Hill Limestone—principally marls.

Orleton Court has a piped supply from a spring, but otherwise the parish is dependent on wells.

Overbury.—Maps : 200, 216, 217 ; 44 ; 48 S.E., 49 S.W., 55 N.E.

A long narrow parish extending from the top of the northern face of Bredon Hill southwards to the Carrant Brook. An east-and-west fault crosses the parish about 400 yds. north of the church. The beds to the north, which dip southwards towards the fault are Inferior Oolite, resting on Upper Lias clay, which is exposed at the surface in Overbury Park. The rain which falls on the Inferior Oolite sinks through, travels southwards along the inclined surface of the underlying Upper Lias clay by which it is thrown out in the Park. No water from the Middle Lias (such as supplies the Combertons and Elmley Castle) comes out in Overbury Park : that formation lies too far below the surface in this tract. South of the fault is Lower Lias, covered near the hill by much slabby ' gravel ' derived from the hill, and farther south by well-rolled Oolite gravel.

Overbury village is provided by an undertaking belonging to Holland Martin of Overbury Park from a spring out of Inferior Oolite on Upper Lias clay some 120 yds. E.N.E. of Silver Rill House and ½ mile N.E. of Overbury

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[1] Tomlinson, M.E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, Pl. X.

[2] *Trans. Worcs. Nat. Club*, vol. for 1847–96 (1897), p. 156 ; L. Richardson, *ibid.*, vol. viii, pt. 3 for 1925 (1927), p. 148.

Church. From the adjoining reservoir (12,000 gallons) the water is laid on to the houses in the village and to a public fountain [1] (analysis No. 427). The daily average supply is 14,000 gallons.

A spring near Park Farm $\frac{15}{16}$ths mile N. by E. of the church supplies Kemerton Castle ; another, $\frac{5}{8}$ths mile N. by E. of the church, is conveyed to troughs in the Park (by gravitation) ; a ram raises water from a third spring, in the northern part of Overbury Wood, to Park Farm and Lalu Farm ; a fourth (in the valley north of Conderton, east of Surman's Plantation or $\frac{7}{8}$ths mile E.N.E. of Overbury Church) supplies water to houses in Pigeon Lane, while a ram close beside it raises water to Shalden Farm. There are other smaller supplies, but the above are the principal ones.

The stream that flows through the garden of the agent to the Overbury Estate is the product of all the principal springs in the ' Overbury Valley ' and varies from 270,000 to 800,000—rarely 1,000,000—gallons per day.

In the southern portion of the parish springs issue from the gravel that rests on the Lower Lias clay.

Pedmore.—Maps : 167 ; 54 N.W., 62 S.W. ; 4 S.W., S.E., 9 N.W., N.E.

In the north-east are Upper Coal Measures (Halesowen and Keele Beds. and Trappoid Breccia), separated by a fault, about $\frac{1}{4}$ mile E. of the Bromsgrove Road, from downthrown Lower Keuper and Upper Mottled Sandstone. The parish is essentially a residential district, and almost entirely supplied by the Stourbridge and District W. B. The following information is derived from E. B. Marten [1] : " . . . particulars of four springs yielding extremely good water and sufficient for supplying the village of Pedmore, just upon the borders of the great western boundary fault of the [South Staffordshire] coalfield. . . ." These seem to come from Wychbury Camp Hill capped by the Trappoid Breccia, " which receives the rainfall and holds it like a sponge on the somewhat dense rock [Keele or Enville Beds] below, springs showing themselves all around 500 feet above sea-level at the base of the Breccia at Pedmore and Hagley and forming the head of riverlets. Within the last few weeks the water has been analysed by Dr. Bostock Hill, and found to be very good as follows :—Parts per 100,000 : total solid impurity 20.0 ; organic ammonia, 0.002 ; free ammonia, 0.001 ; chlorine, 2.5 ; temporary hardness, 5.43 ; permanent hardness, 9.57 ; total hardness, 15.00."

On the west side of the fault the rainfall sinks in the far more porous Triassic sandstones " so that at Hagley the few wells are 70 feet deep, and at Pedmore there are no deep wells and the few that are shallow easily get contaminated." The general level in the New Red Sandstone is about 250 ft. above the sea, the River Stour being the lowest outlet at a point about one mile below the Wollaston Pumping Station, where it is about 200 ft. above sea-level.

W. Wickham King informs me that Marten's " Pedmore Spring " issues from the Keuper Waterstones close to the boundary fault along the side of Wychbury Hill, at a point some 10 or 20 ft. below the 500-ft. contour, and has been used for many years : it now supplies about 25 houses, belonging to the Feoffees of the Oldswinford Hospital and The Rectory. He adds that it is a much better water than the Stourbridge water as it has in it much less lime so that kettles and boilers do not so soon become encrusted. The spring is arched over with brick-work and there is a considerable overflow allowed to run away down into the Rectory Lane. " There is another spring at Pedmore—where the Ham Brook begins. Villagers say it does the eyes good to wash them with it. It is not used at all as a water-supply. The beds here are Keele marls and cornstones."

[1] A sample from the fountain was partially examined in 1894 by E. W. T. Jones, Borough Analyst of Wolverhampton, who reported " in every respect it seems a good water for drinking."

[1] Committee on Underground Waters, *Rep. Brit. Assoc.*, 1886, p. 239.

Pendock.— Maps : 216 ; 43 N.E. ; 53 S.E., 54 N.W., S.W.

This parish, which is in two portions separated by that of Berrow, is on Keuper Marl—including the Arden Sandstone, quarried at Burghill. These beds have been gently flexed [1] and are probably from 800 to 1,000 ft. thick beneath the parish.

The supply is from wells and mostly adequate in spite of dry seasons : shortage at any particular house has generally been due only to a need for cleaning or repair. The Rev. H. F. Crennell, the Rector, informs me that, on the whole, the two methods of supply are equally divided in the parish. In the main area, including the Rectory and village, probably most wells are fitted with pumps ; those in the detached portion at Cromer Green are practically all open, and he only knows for certain of one which has a pump. The well at Prior's Court is believed to be 72 ft. deep and that at the School House about 50 ft.

Pensax.—Maps : 182 ; 55 N.E. ; 13 S.W., S.E., 20 N.W., N.E.

Roughly speaking, the northern and highest part of the parish is on Coal Measures, as much as 130 ft. thick, that rest on " Lower " Old Red Sandstone. The parish is dependent on wells and a few springs. There have not been any complaints of shortage.

Peopleton.—Maps : 199, 200 ; 54 S.W. ; 34 S.E., 41 N.E.

On Lower Lias clay, with local traces of gravel.

The village is on the clay and the water-supply is bad. There are two public wells by the ditch side : in one the supply fails every summer, in the other it is persistent, but both have been condemned. The private wells are shallow, and many yield saline water contaminated with surface drainage so that many of the villagers have to bring their supplies from the public wells. 94% of the analysed samples were found " unfit for drinking purposes." " The water at Seaford Grange ' smells when it gets low ' ; and that at two adjacent cottages is brackish. A rain-water tank for drinking purposes was provided when these cottages were built, but the tenants told me they carried their drinking water either from Seaford Grange or Naunton Brook. One other house also could not be certified under the Public Health Water Act, until a rain-water tank was provided." [2]

Pershore Holy Cross.—Maps : 199, 200 ; 54 S.W. ; 34 S.W., 41 (4 qrs.).

This parish includes the greater part of the country town of Pershore (dealt with separately below), Crab Common, Walcot, Stonebow, Chevington, etc. It lies on Lower Lias with local deposits of sand [3] and gravel, some of them portions of river-terraces.[4]

At Drakes Broughton many of the wells yield scanty supplies and in others the water is brackish. The wells locally most favoured are those sunk in a gravel-bed near the Church, where there is a public pump over a well some 20 ft. deep and always practically full. Many persons resort to a well in a field (known as Taylor's Orchard) about 300 yds. from the village.[5]

All the samples analysed proved either to be unfit for drinking purposes or to give evidence of past contamination.[6] The water in one well smelt of sulphuretted hydrogen. Rain-water tanks have been provided at a number of houses.

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[1] Richardson, L., *Proc. Cotteswold Nat. F. Club*, vol. xv, pt. 2, 1905, pp. 93–100 ; *Quart. Journ. Geol. Soc.*, vol. lxi, 1905, pp. 425–430.

[2] Fosbroke, Dr. G. H., Reports on the Water Supplies . . . in the Pershore Rural District. *op. cit.*, p. 37.

[3] A pit west of Pigeon House shows 6 ft. of sand, with a few pebbles of quartz and quartzite, resting on the *Oxynotus* clays of the Lower Lias.

[4] Tomlinson, M. E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, Pl. X.

[5] Fosbroke, G. H., *op. cit.*, p. 20.

[6] *Ibid.*, p. 20.

Wells about 15 ft. deep have been sunk in some of the gravel bordering the Worcester road. Many of the newer houses at Wadborough are dependent on rain-water tanks.

Mr. Jacques informed me that wells sunk in Lower Lias clay, to the right of the road from Pershore Station to Pershore town, and to the left as far as where the road to Wyre Piddle leaves it, yielded no water—" the deeper they go, the dryer the clay gets." Some 500 yds. along the Wyre Piddle road one well (Pershore Holy Cross Building Scheme) proved :—

	Blue clay : about 6 ft.	} 25 ft.
	Clay and sandy material [1] ...	
[Lower Lias]	Greyish rock	

and a constant supply of good water was obtained. But between this and the point where the Wyre Piddle road leaves the Station–Pershore town road, other wells sunk in the same ' sandy material ' yielded water as brackish as any found in the Lower Lias of the district. The water in the wells beside the lane running from the last-mentioned point to Wyre Piddle Mill decrease in salinity as the distance from that point increases.

Pershore Town

The greater portion of this Avon-side town is on sand and gravel (river terrace) [2] which rest on Lower Lias. The Lower Lias rises from beneath the sand and gravel in the smaller north-western portion of the town.

The town is supplied from large numbers of shallow wells the average depth of which is from 12 to 18 ft. Dr. G. H. Fosbroke has published the following particulars [3] :—

	In Year	
	1893	1905
No. of houses without drinking water on premises	71	64
Often short	65	123
No. of wells suspected by Inspector of being contaminated but not analysed	43	48
No. of open draw wells	29	29

1906					
Wells analysed	45	supplying	148	houses.
No. Bad	35	,,	130	,,
,, Suspicious...	1	,,	2	,,
,, Undesirable	5	,,	10	,,
,, Good	4	,,	6	,,

" It should be mentioned that 22 houses built in the town since had to be supplied with rain-water tanks for domestic use. . . ." The house of J. J. Jacques, former Sanitary Inspector, is on the ' sand-bed.' It has a well about 20 ft. deep. The water is on the brackish side, especially after heavy rains, but the quantity is maintained, and during the drought of 1921 supplied 30 families.

At the Police Station, also on the ' sand-bed,' is a well about 15 ft. deep. In it the supply is constant, but never more than 3 ft. deep. Water from it is pumped up by a petrol engine to the County Council Cottages on the Worcester

[1] ' Sandy material ' may be an erroneous description of a Lias deposit, or, on the other hand, may be correct—descriptive of a superficial deposit in a fissure that was cut through in the sinking.

[2] Tomlinson, M.E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, Pl. X.

[3] *Op. cit* p. 18.

Road, where a well had been sunk 72 ft. deep in clay without tapping a satisfactory supply.

The supply of Pershore and certain villages in the Pershore Rural District with an adequate supply of wholesome water has long been a pressing need. Many sources have been considered—springs at Hill and Moor, Wyre Piddle, Elmley Castle, Overbury, Kemerton, Rous Lench, Buckland, Stanton, Stanway, Toddington, etc., the Walcot and Wyre Brooks, and the River Avon—whose waters on analysis proved to be contaminated with sewage or animal matter and are on the hard side.

Pershore St. Andrews.—Maps : 199, 200 ; 44, 54 S.W. ; 41 S.E., 48 N.E.

This parish stretches athwart the River Avon and includes part of Pershore town. It is on Lower Lias with local sand and gravel, and alluvium.

The village, at Pensham, is on sand and gravel and there does not appear to be any shortage of water although none of the well-waters were reported as fit for drinking purposes.[1]

In gravel alongside the river, about 1⅛ miles S. by E. of the Abbey is a well from which water is raised by a windpump to a tank alongside to supply 24 houses in the vicinity—the property of the Ecclesiastical Commissioners.

At the corner of a triangular piece of ground, bounded by roads near the Cemetery, a spring discharges into a trough below some rustic stone-work.

About a quarter of a mile from the Cemetery, on the right-hand side of the road to Defford, is a new house with a well, sunk 40 ft. deep in Lower Lias clay, and a windpump. No water was encountered in sinking the well : any water collecting in it is mainly surface water : Tiddesley Wood above the house is on water-logged clay ground.

Pinvin.—Maps : 199, 200 ; 54 S.W. ; 41 N.E.

On the Lower Lias clay, with a local covering of sand and gravel. Gravel and sand that has found its way down fissures, etc., is occasionally encountered in wells in the Lower Lias.

The village is mostly on clay, but near the Church is a vein of sand in which there is a useful supply of good water.

The water supply on the whole is bad. It is derived from shallow wells, the yield is scanty, and the water from the wells at the lower or southern end of the village is considered unpalatable—especially in the autumn. Twelve cottages, known as ' Pershore Terrace,' are supplied by two wells and a rain-water tank of 9,000 gallons capacity, and the water before being collected is passed through a sand and gravel filter. The occupier of the ' Coventry Arms ' has to carry the water required for potable purposes from a well sunk in a field (in Pershore Holy Cross parish) by the road (leading to ' Walcot Ford ') near the Atlas Iron Works. Of this water Mr. Duncan reported on October 31st, 1908, that it " is hard and contains much mineral matter in solution. Otherwise the water is satisfactory."

According to Dr. Fosbroke, water for use at the Jam Factory (now a motor garage), near the G.W.R. Station, is drawn from the Walcot Brook . . . and distilled ; rain-water is collected for the engine. The G.W.R. Station House is supplied with crudely-filtered rain-water and on October 16th, 1908 the rain-water tank was empty so that water had to be carried from the station well (the water of which on analysis turned out to be ' unfit for drinking purposes '). This well was also drawn upon by one or two people living at ' Pershore Terrace ' and ' Coventry Terrace.' Only 12.1 per cent. of the samples analysed from this village were, on analysis, pronounced ' fit for drinking purposes.' [1]

During the drought of 1921, Pinvin was the first village in the Pershore Rural District to experience shortage and water had to be carted there from the River Avon.

[1] Fosbroke, G. H., *op. cit.*, p. 23.
[1] Fosbroke, G. H., *op. cit.*, p. 29.

Pirton.—Maps : 199 ; 54 S.W. ; 40 N.E., 41 N.W., S.W.

The village and western portion of the parish are on Keuper Marl ; the larger and sparsely populated eastern portion is on Lower Lias. Sand and gravel occur locally at the village and elsewhere.

The village is dependent on wells and the supply of water is " just sufficient " (J. J. Jacques). The well at Small Holdings Cottages is 90 ft. deep in " red rocky " (Keuper) marls and has 9 ft. of water.

Pirton Pool, on the Lower Lias, was considerably shrunken by the drought of 1921.

Powick.—Maps : 199 ; 54 S.W., 55 S.E. ; 33 S.W., S.E., 40 (4 qrs.).

A rather large parish on Keuper Marl, with local surface sand and gravel and, bordering the Rivers Severn and Teme, Alluvium. Stanbrook, King's End (new well ; analysis No. 457), Callow End and Beauchamp Court on sand and gravel ; but around Woodsfield the soil is mostly marl.

Powick village is partly supplied by a small undertaking belonging to the Rural District Council. A spring issuing from a river terrace sand and gravel bed at Ham Hill (half a mile N.W. by N. of the Church) collected by puddling and agricultural pipes and conducted through a settling-tank into a reservoir (both at the spring head) gravitates into a cemented well behind the pump-house on the south side of the road on the low ground in the village. It was originally intended to obtain the public supply from the well at the back of the pump-house ; but in those days the drainage of the village went into the streamlet that runs near the well, so there was danger of pollution. All the drinking water is said to be obtained from the pump. There are wells in use, however, for other than potable supplies, and since the installation of the sewage scheme the quality of the well-water has greatly improved.

The County of Worcester Mental Hospital is supplied with Worcester City water.

Queenhill.—Maps : 216 ; 43 N.E., 44 ; 47 S.E., 54 N.E.

This parish, which is dependent on wells, lies for the most part on Keuper Marl, but the high ground is composed of the topmost beds of the Keuper, the Rhaetic, and basal limestones and clays of the Lower Lias.

Redmarley D'Abitôt.—Maps : 216 ; 43 N.E. ; 53 N.E., S.E., 54 S.W., 59 N.E.

The western portion of this parish, including the village, lies relatively high on the Lower Keuper Sandstone ; the much larger, lower eastern portion is on Keuper Marl, faulted against the Sandstone, with local deposits of sand and gravel (" Northern Drift ").

The abundant water in the Lower Keuper Sandstone is held up by certain marly beds and thus thrown out as small springs or made available in shallow wells (as at Murrell's End and Cobhill Cottage) and dip wells (as north of Payford Bridge) in the mural sandstone sides of lane cuttings. In those cases where water so held up is not encountered, wells must go much deeper to ensure a perennial supply. The depth of the Leadon valley causes a lowering of water-table in the contiguous sandstone masses. The water-table also rises and falls between well-separated limits according to rainfall, while the Pumping Stations of the Malvern Urban District Council at Bromsberrow Heath and of the Gloucester Corporation at Ketford have made their existence felt over certain areas.

In the valley of the Leadon at Durbridge (Fig. 3, Nos. 3 and 4) some strongly saline (common salt) springs (analysis No. 627) discharge into the river ; while close by a a good fresh-water spring (Fig. 3, No. 5).[1] The source of the salt is obscure.

[1] See *Proc. Cotteswold Nat. F. Club*, vol. xxi, pt. 2 for 1922 (1923), pp. 156–158.

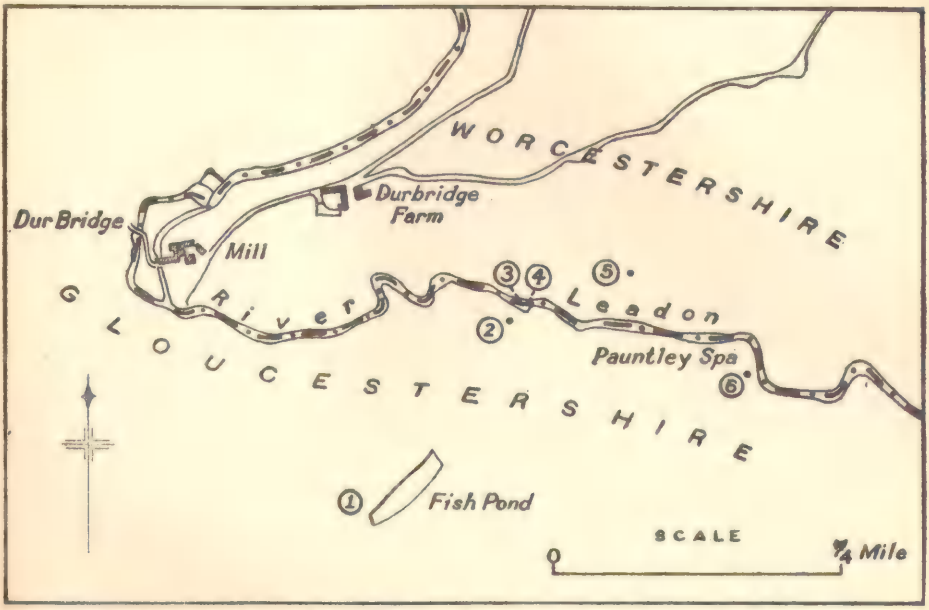

FIG. 3.—*Map showing sites of springs in the Leadon Valley.*

The following are particulars of wells in the Lower Keuper Sandstone, obtained by E. F. Brading, Sanitary Inspector to the Newent (Glos.) Rural District Council :—

Site	Height above O.D. (feet)	Depth of well (feet)	Depth of water in well (feet)	Greatest depth of water recollected (feet)
Hazeldine (" Pfera Hall " on the 6-in. map 53 S.E.) ...	About 250	About 70	—	—
Hillfields House	About 250	150	—	—
Hyde Park Corner, Redmarley village	262	160	7	7
Village Well (between the Church and School on the west side of the road) ...	About 259	160	4 to 5	7 to 8
Cobhill Cottage (at W. end of Grove Coppice, ½ mile W. by S. of Redmarley Church)	141.8	31	3	4
Murrell's End	About 205	" Quite shallow "	—	—
Durbridge Farm	—	79	3 to 6	—

King's End House and Hillfields House are supplied—Mr. Brading informs me—like Down House, from the Bromsberrow Pumping Station; Bromsberrow Place and Brown's End from a surface spring the water of which is stored in a reservoir.

The wells in the Keuper Marl area are mostly shallow and fitted with pumps. On the whole the supply is adequate and good ; but many give out during a very dry summer.

Ribbesford.—Maps : 182 ; 55 N.E. ; 13 N.E., S.E., 14 N.W., S.W.

Most of the parish is on the Middle Coal Measures, resting directly on Old Red Sandstone. At Stagbury Hill, W. Wickham King informs me, Upper Coal Measures (Halesowen Sandstones, a small thickness of Old Hill Marls and much Trappoid Breccia) succeed. From a W.S.W.–E.N.E. fault in these Halesowen Sandstones issue springs, such as those utilized for the supply of Stagbury Hill Cottage and Coneygreen. Small portions of the parish, as at Ribbesford Church and Coneygreen, are on Bunter beds faulted against the Palaeozoic rocks.

The houses in the parish are very scattered and are dependent on wells, springs and brooks.

Ribbesford Hall.—The house and a few cottages, Mr. Llewellyn informs me, have a piped supply of good water from a perennial spring in Coal Measures in the woods at the back of the house.

Coneygreen.—Stagbury (or Stagborough) Hill Cottage is supplied from a spring, as referred to above ; the water is collected in a brick chamber. Other springs of like origin, in the ground between the Gladder Brook and the bridle road from the Cottage to Coneygreen, are collected into a large brick tank and gravitate to Coneygreen.

Wickham King informs me that there is an approximately N.–S. fault up the east side of High Oak Coppice on the north-west side of Botany Bay Coppice, marked by a line of strong springs and marshy ground (Halesowen Sandstones). The greatest quantity of water would be got in a well sunk a little north-west of the brick tank where the ground is so marshy, and would come from the north and west.

Ripple.—Maps : 199, 216 ; 44 ; 47 N.E., S.E., 48 S.W., 54 N.E., 55 N.W.

Ripple village lies on the Arden Sandstone : the remainder of the parish is on the Keuper Marl on the surface of which is, locally, sand (as at Ryall) and gravel. There is alluvium beside the River Severn.

The parish is adequately supplied by wells, but many of them are polluted.

Rochford.—Maps : 181 ; 55 N.E. ; 19 N.W., N.E., S.E.

Except for the high ground at Hill Top in which the Birch Hill Limestone crops out, and alongside the River Teme where there is Alluvium, this parish is on Old Red beds—principally marls—under the Birch Hill Limestone. It is dependent on wells.

Rock.—Maps : 182 ; 55 N.E. ; 7 S.W., S.E., 13 (4 qrs.), 14 S.W., 20 N.E., 21 N.W.

A large parish of 8,772 acres. The eastern portion, around Heightington, is on much-disturbed and furrowed Old Red Sandstone, succeeded in the north and west by Coal Measures.

The parish derives its water from draw wells and wells fitted with pumps. The supply is moderate but does not run out. There are two public wells, both in Coal Measures and drawn by hand-pails :—(1) at Thumpers Hole, Callow Hill, 3 ft. 6 in. deep with usually 3 ft. of water in it ; (2) at Cross Bank Rock, 2 ft. 2 in. deep, usually full of water.

The Acre Farm, The Woodlands, Far Forest, and Organ Hill Farm are supplied by brook-water forced up by rams. At White House, Far Forest, brook water works a ram which raises drinking water from a spring.

Water from a well in Old Red Sandstone 40 ft. 6 in. deep, which on August 10th, 1923 had 7 ft. 9 in. of water in it, is raised by windpump to Upper Snead, Rock. At Lye Head two rams force up spring water for the supply of several farms (H. E. Pritchard, Bewdley Hill, Kidderminster).

On the Geological Survey Map (Old Series), 55 N.E. the word " Holywell " appears west of Gibhouse Farm. The existence of a holy well is not known locally ; but as long as an old resident could recollect the little-used lane from the farm to Tanner's Brook had been called Holywell Lane.

The Coal Measures proved to be 269½ ft. thick at Blakemore or Blakemoor Colliery, 181 ft. or more at Gybhouse Colliery, and at least 601 ft. in the Yewtree sinking and boring.[1]

Romsley.—Maps : 167, 168, 182, 183 ; 54 N.W., 62 S.W. ; 9 N.E., S.E., 10 N.W., S.W.

The greater part of Romsley parish is on Upper Coal Measures ; Trappoid Breccia succeeded by Bunter Pebble Beds comes on in the extreme southern part, and there is an area of boulder clay north and east of Gannow Farm.

The village is served by the South Staffordshire W. Co., whose mains extend to Romsley Hill and Sanatorium. The remainder of the parish is dependent on wells, some fitted with pumps, others draw wells, the sufficiency and quality of the water in which are said to be satisfactory.

BORING AT ROMSLEY HILL

Site.—At house on south-west side of Romsley, near Great Farley Wood adjoining Romsley Sanatorium.

Made in 1906 and particulars communicated by Messrs. H. Brown & Co.

Surface-level.—850 ft. above O.D.

Boring (diameter 4 in.) :—

			Thickness Ft.	In.	Depth Ft.	In.
[Bunter Pebble Beds]	1.	Coarse gravel	18	0	18	0
	2.	Hard sandstone	22	0	40	0
	3.	Conglomerate	11	0	51	0
	4.	Hard sandstone	43	0	94	0
	5.	Conglomerate	2	6	96	6
	6.	Hard sandstone	15	0	111	6
	7.	Conglomerate	18	0	129	6
[Probably Trappoid or Clent Breccia higher beds]	8.	Sandstone, softer ...	4	0	133	6
	9.	,, hard... ...	32	0	165	6
	10.	,, very hard ...	12	0	177	6
	11.	,, hard (water tapped)	22	0	199	6
	12.	,, softer ...	31	6	231	0

Water-level, 198 ft. ex surface. Yield, 15 gallons per hour.

The Company's water is now laid on to the house and the above source of supply is no longer used.

Rous Lench.—Maps : 200 ; 54 S.W. ; 35 (4 qrs.), 43 S.W.

This parish is mainly on Keuper Marl ; but Rhaetic (black shales, etc.) capped with the basal clays and limestones of the Lower Lias, occurs in the high ground ranging from east to south-east of the village. Locally there is superficial sand and gravel.

The village, on the Keuper Marl, is adequately supplied with water by wells varying from 15 to 80 ft. deep. Mr. Chafy, of Rous Lench Court, has never heard of any shortage in the village, even in the driest summer like that of 1921. He informs me that " the wells in the village are all in the red marl,

[1] For further details *see* E. A. Newell Arber, *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, 1914, p. 380.

and the water is generally found in a layer of sandstone. All the supplies in the parish are private, there being about one well to every four or so cottages. There are no springs running to waste."

Rous Lench Court.—H. E. Chafy has supplied the following information concerning several borings made some time ago near The Court :—Nos. 1, 2 and 3 [see below] were all failures, in spite of the fact that the bank in which 2 and 3 are situate is known to be full of water. These were done by hand without the aid of a diviner. No. 1, a complete failure, was sunk on the advice of a diviner who was positive that water was present at from 150 to 200 ft., but none was found—not even at 278 ft. when it was abandoned. No. 4 was found quite at random : it was originally an artesian well with a 6-inch bore, but this proving insufficient was sunk two feet lower and the size increased to 6 ft. in diameter. At 33 ft. is a bed of limestone (locally known as 'firestone'), 4 ft. thick, which contains water. This supply proving insufficient after a year's pumping the well was sunk another 2 ft., when a bed of limestone was struck, which contained more water. Up to the present this supply has been quite adequate : in spite of the great dryness of 1921 there was never less than 7 ft. of water, about the normal amount, in that year. It is pumped by windmill into a 23,000-gallon tank at the top of the garden, from which it gravitates to the Court.

BORINGS AT AND NEAR THE COURT, ROUS LENCH

No. 1.—*On the Common*

			Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Drift, Lower Lias and Rhaetic]	1.	Soil	2	0	2	0
	2.	Sand	1	0	3	0
	3.	Red clay	3	0	6	0
	4.	Sand	3	0	9	0
	5.	Red clay	1	0	10	0
	6.	Sand	4	0	14	0
	7.	Red clay	20	0	34	0
	8.	Blue clay	5	0	39	0
	9.	Yellow clay	5	0	44	0
	10.	Grey stone	2	0	46	0
	11.	Hard grey clay	8	0	54	0
	12.	Blue stone	2	0	56	0
	13.	Grey clay	22	0	78	0
	14.	Shale	1	0	79	0
	15.	Blue clay	9	6	88	6
	16.	Blue stone	1	6	90	0
	17.	Blue clay	4	6	94	6
	18.	Blue stone	1	0	95	6
	19.	Blue clay	3	6	99	0
[Keuper]	20.	[? Tea-green Marls] Grey clay and stone	25	0	124	0
	21.	Red Keuper Marl	154	0	278	0

Result.—No water. Bore abandoned.

No. 2.—*On the south side of the road opposite the Court*

			Thickness Feet	Depth Feet
[Lower Lias and ? Rhaetic]	1.	Yellow clay	14	14
	2.	Shale	1	15
	3.	Yellow clay	2	17
	4.	Grey clay and stone	4	21
	5.	Hard grey clay	7	28
	6.	Stone and clay	2	30
	7.	Hard grey clay	5	35
	8.	Black clay and stone... ...	6	41
	9.	Black clay	9	50

Result.—No water. Bore abandoned.

No. 3.—*On the south side of the road opposite the Court*

		Thickness Feet	Depth Feet
[Lower Lias and Rhaetic]	1. Yellow clay	2	2
	2. Red clay	1	3
	3. Hard grey clay	7	10
	4. Shale	2	12
	5. Hard grey clay	11	23
	6. Hard black clay	4	27

Result.—No water. Bore abandoned.

No. 4.—*A little to the south of Nos. 2 and 3*

		Thickness Ft.	In.	Depth Ft.	In.
[? Some Drift on Lower Lias]	1. Soil	2	0	2	0
	2. Red clay	6	0	8	0
	3. Yellow clay	8	6	16	6
	4. Sand	0	6	17	0
	5. Yellow clay	14	0	31	0
	6. Black clay	2	0	33	0
	7. Stone containing water ...	4	0	37	0
	8. Hard grey clay	1	0	38	0
	9. Limestone	1	0	39	0

Water level.—32 ft. ex surface.

Rushock.—Maps : 182 ; 54 N.W. ; 14 S.E., 15 S.W. 22 N.W.,

This parish is on Keuper Marl, giving rise to heavy ground with local traces of gravel on the surface. In the extreme west is found Lower Keuper Sandstone, dipping underneath the marl.

Village and parish are dependent on shallow wells fitted with pumps. D. Llewellyn, Sanitary Inspector, informs me that there is no record of there having been any shortage of water in the parish.

St. John in Bedwardine County (close to Worcester City).—Maps : 199 ; 54 S.W., 55 S.E. ; 28 S.W., 33 (4 qrs.).

This parish (3,348 acres) is on the Keuper Marl, with a local capping of gravel and sand, and a strip of flat alluvial meadow-land beside the River Teme. The ferruginous water from the gravel and sand, which is exposed in the railway cuttings between Henwick Station and the River Teme, caused trouble with the permanent way and had to be drained out of the cuttings.

The parish is dependent on wells with the exception of one house, which has Worcester City water laid on.

St. Peter the Great County (near Worcester City).—Maps : 199 ; 54 S.W. ; 33 N.E., S.E., 34 S.W.

On Keuper Marl, with local sand and gravel and, down by the River Severn, Alluvium.

Norton Barracks and about 20 houses in the parish are supplied from the City Waterworks ; otherwise the parish is dependent on wells.

St. Martin County (near Worcester City).—Maps : 199 ; 54 S.W. ; 33 N.E., 34 N.W.

This parish is on Keuper Marl with traces of gravel, and is dependent on wells.

Salwarpe.—Maps : 182 ; 54 N.W., S.W. ; 28 N.E., 29 N.W., S.W.

On Keuper Marl, with local surface deposits [1] of sand and gravel (drift).

The parish is dependent on wells, some of which, according to P. F. Kett, the Sanitary Inspector, have to go 40, 50 and 60 ft. deep in order to be sure of water.

[1] Sand is dug from time to time in the ground south of the smithy opposite ' The Copcut Elm ' on the Droitwich–Worcester road.

Sedgeberrow.—Maps : 200, 217 ; 44 ; 49 S.W., S.E., 56 N.W., N.E.

On Lower Lias clay ; locally, deposits of gravel. Served by the Evesham and Pebworth Joint W. Com. undertaking, practically all the houses having the water laid on.

Severn Stoke.—Maps : 199 ; 44, 54 S.W., 55 S.E. ; 40 N.E., S.E., 41 S.W., 47 N.E., 48 N.W.

On Keuper Marl, in which is developed the Arden Sandstone, with a local covering of sand and gravel, and Alluvium beside the River Severn. The lower portion of Severn Stoke village is on sand (fine and excellent for building purposes) ; the upper, on the Marl.

Village and parish are dependent on wells. On one occasion the water in the well at Severn Bank was found to be 'salty.' In Kinnersley the wells are shallow.

Shelsley Beauchamp.—Maps : 182 ; 55 N.E., S.E. ; 20 S.W., S.E., 27 N.E.

The larger western portion of the parish is on the lower beds of the Old Red Sandstone, the Silurian rising from beneath them in the eastern part. The village itself is on Teme-side Alluvium. Prof. Groom [1] has shown that the structure of the Silurian is much more complex than would appear from the existing geological map.

The parish is dependent on wells, but there are several small springs. (See also Shelsley Walsh).

Shelsley Kings.—Maps : 182 ; 55 N.E. ; 20 S.W., S.E.

For the most part on the Old Red Sandstone ; but a narrow tongue of Coal Measures projects southward from the main coalfield, running along the eastern portion of Kingswood Common, and Silurian appears from beneath the Old Red in the vicinity of Walsgrove Hill.

The parish is dependent on wells.

Shelsley Walsh.—Maps : 182 ; 55 N.E., S.E. ; 20 S.W., S.E., 27 N.W., N.E.

Roughly speaking, the north-eastern half of this parish is on Teme-side Alluvium, and the rest on Old Red Sandstone, the Birch Hill Limestones cropping out in Coomb Hill.

According to information received from H. Tayleur, Court House Farm has a clear-water gravitation supply from the hill above ; also the brook is dammed near the top of the motor-test road, forming a small reservoir, which gives power to a turbine at the farm where there is also a water-wheel worked from the brook. A ram not far from the reservoir forces brook water to the farm buildings on higher ground.

The source of the clear-water supply is a spring situate near the top of the same road. It seems to be a strong spring, and a supply from it is piped across and beneath the Teme to Brockhill Court, in the parish of Shelsley Beauchamp.

Shipston-on-Stour.—Maps : 200, 201 ; 44 ; 51 N.E., S.E., 52 N.W., S.W.

A detached parish on Lower Lias clay, with local Glacial gravel.

The town (population 1,365) is almost entirely on clay, but there is a very small gravel-bed in the west end. As might be expected, the wells, on which the town formerly depended, were unsatisfactory, and almost all polluted. Some of the waters, even from wells in the gravel-bed, were of a slightly aperient nature, and there was shortage.

Since 1901 the town has had a good supply from a spring issuing from the Sandy Beds of the Middle Lias near Ebrington village (Glos.), 4 miles to the west. By the purchase agreement with Lord Fortescue only 40,000 gallons

[1] Groom, T. T., *Quart. Journ. Geol. Soc.*, vol. lvi, 1900, pp. 164, 168–69.

per day may be taken. The reservoir (40,000 gallons) is on the north side of the road about midway between Ebrington and Shipston-on-Stour, and practically all the houses in the town are connected with the mains.[1]

Shrawley.—Maps : 182 ; 55 N.E. ; 21 N.W., S.W.

The northern and greater portion of the parish is on Lower Keuper Sandstone, the rest on the succeeding Keuper Marl. The Sandstone country is deeply furrowed and in Shrawley Woods are a number of pools.

The parish is dependent on wells.

South Littleton.—Maps : 200 ; 54 S.E. ; 42 S.E., 43 S.W.

Mainly on Lower Lias (clays and limestone-bands) ; but the Rhaetic and topmost beds of the Keuper Marl crop out in the steep bank in the western extremity of the parish. Practically all the houses have the Evesham and Pebworth Joint water laid on.

Spetchley.—Maps : 199 ; 54 S.W. ; 34 N.W., S.W.

Spetchley parish is on the upper portion of the Keuper Marl, and includes outcrops of the Arden Sandstone.

Spetchley Hall and five out of some 25 houses in the parish are supplied from the Worcester Waterworks mains [2] : the others are dependent on wells, the water in which is said to be satisfactory.

Stanford-on-Teme.—Maps : 182 ; 55 N.E. ; 20 N.W., S.W.

This parish is on Old Red Sandstone, with Alluvium down by the River Teme. The greater part is on beds (principally marls) below the horizon of the Birch Hill Limestone, which crops out in the high ground along the south-western boundary.

H. Tayleur, Agent to the Stanford Estate, has communicated the following information :—

" Stanford Court.—Gravitation supply from spring on Park Farm. The average yield is about 1,500 gallons per day, but the spring is apt to become enfeebled in a very dry period.

Stanford Rectory.—Gravitation supply from spring in glebe lands.

Fall Farm.—Supplied by probably the strongest spring in the parish which yields about 10 gallons per minute, pumped up by a ram.

School House and cottages near.—Supplied by gravitation from glebe lands.

The rest of the parish, so far as I know, is supplied from wells. The main collections of water are a brook running down by Southstone Rock, another by Noverton Farm, and another from The Fall Farm through the glebe—all reaching the River Teme. The big pool at Stanford Court, of 20 acres, is fed in part from the brook by Noverton and in part from that going through the glebe land—the supply is not very adequate.

I do not know of any abundant supply that could be used for any but local purposes."

Southstone Rock is a great mass of travertine, formed by springs issuing from the Birch Hill Limestone (cornstone), and affords impressive evidence of ready deposition of calcium carbonate held in solution in the water as bi-carbonate.[3]

Staunton.—Maps : 216 ; 43 N.E. ; 59 N.E., S.E., 60 N.W.

Staunton parish is on Keuper Marl, with an outcrop of Arden Sandstone immediately east of the Glynch Brook. There is a sprinkling of sand and gravel (Northern Drift).

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[1] Honington (Warwicks.), 1¼ m. N.N.E. of Shipston, is also supplied from the same mains.

[2] Supplied in bulk to the Pershore Rural District Council.

[3] For archaeological associations of the ' Rock,' see Sir Thomas E. Winnington in *Worcester Diocesan Architectural and Archaeological Soc.*, vol. vii, 1863, pp. 133–36 ; and Edwin Lees, ' Pictures of Nature . . . around the Malvern Hills,' 1856, pp. 245–47. See also *Trans. Worcs. Nat. Club*, vol. for 1847–96, p. 212 ; *ibid.*, vol. vii, pt. iii, 1920, pp. 270–272.

The parish is dependent on wells, mostly dry in the average summer, and shallow. The well at Staunton Court is 23 ft. deep and on August 24th, 1923. had 5 ft. of water in it.

Stock and Bradley.—Maps : 183, 200 ; 54 N.W., S.W. ; 23 S.W., 30 N.W., S.W.

Stock and Bradley hamlets are on Lower Lias clay.

The parish is dependent on wells from 9 to 30 ft. deep. The water in some of the deeper wells is saline, and some time ago a well at Stock Green was found after deepening to yield water too saline for household use. Shortage is experienced locally in very dry periods.

Stockton-on-Teme.—Maps : 182 ; 55 N.E. ; 20 N.W., S.W.

Except for a very small area of Coal Measures in the north, this parish is on Old Red Sandstone. It is dependent on wells.

Stoke Bliss.—Maps : 181 ; 55 N.E., S.E. ; 19 S.W., S.E., 26 N.W., N.E.

This parish is in two parts, separated by Kyre Parva. In the high ground (south portion of the south-western part and east portion of the eastern part) crops out the Birch Hill Limestone. The ground below is on underlying beds —mostly marls.

The spring that supplies Kyre House issues from the Birch Hill Limestones near Garmsley, while water from a well in their neighbourhood is syphoned for the supply of Thorn Farm ; otherwise the parish is dependent on wells.

Stoke Prior.—Maps : 182, 183 ; 54 N.W. ; 15 S.E., 16 S.W., 22 N.E., S.E., 23 N.W., S.W.

Finstal, Bromsgrove Station, Woodgate and Stoke Works are all in this parish, the northern portion of which is on Lower Keuper Sandstone, the southern on Keuper Marl ; the Lower Lias is just touched at Woodgate, on the downthrow side of a large fault which runs from N.W. by N. to S.E. by S., passing between The Grange and Stoke Court.

The more populated parts near Bromsgrove Station, Aston Field, Finstal and Stoke Works are supplied by the East Worcestershire W. Co. ; the remainder of the parish by wells, the sufficiency and quality of the water in which is said to be satisfactory.

SUGAR BROOK BORING

Site.—Immediately north of road and east of railway by railway arch east of Sugar Brook.

From information given by Mr. Whitemore, formerly Sanitary Inspector for the eastern part of the Bromsgrove R.D., this boring was made about 1912 in search of brine, and was 200 to 300 ft. deep. It was commenced in Keuper Marl, but no doubt entered the Lower Keuper Sandstone, for excellent water spouted out and a drain had to be put in to convey it into the brook.

CHARFORD BORING

Site.—East of brook ¼ mile W.N.W. of Bromsgrove Station.

Made in 1882 in search of brine (in the Lower Keuper Sandstone), and particulars furnished by S. G. Purchas, M.I.C.E., and published in 1889.[1]

Surface-level.—About 238 ft. above O.D.

Boring (diameter, 2¼ in. ; depth, 300 ft.) :—" The boring appears to be wholly in the Keuper Sandstone, which is here traversed by three calcareous beds of ' Rag,' which are probably impermeable. Magnesia occurs in marly partings in the adjacent district."

The borehole overflowed and was never pumped. Quantity gauged in January, 1885, 100 gallons per minute ; in July, 1887, 86.6 gallons per minute ;

[1] *Rep. Brit. Assoc.*, 1889, pp. 73–74.

in October, 1889, 36 gallons per minute, which was the quantity gauged by C. E. de Rance on April 25th, 1888. Thos. Jones informs me (*in litt.*, August 7th, 1923) that the 4-in. pipe is still running and has a cap, fitted with pipe, to force water up to some farm buildings at a higher level some 70 yds. away.

THE WORCESTERSHIRE SALT WORKS,
Stoke Works
(The Salt Union Ltd.)

These works lie on the downthrow side of the fault mentioned above, and about 1½ miles from the escarpment of Lias at Woodgate ; the surface of the ground is probably on beds in the upper half of the Keuper Marl. There are three wells at the works, within 30 yds. of one another. W. Neale informs me that the exact depth of Shaft No. 1 is 232 ft. 10 in., and of the borehole 125 ft. 7½ in., making 358 ft. 5½ in. in all ; also that the depths of the other two wells are approximately the same.[1]

Stone.—Maps : 182 ; 54 N.W. ; 8 S.E., 9 S.W., 14 N.E., S.E., 15 N.W.

The north-western part of the parish is on Upper Mottled Sandstone, succeeded by Lower Keuper Sandstone south-east of a line passing a short distance north-west of the church. Much water issues near the junction of the two formations, giving rise to streams that have been impounded to supply power to mills.

The parish is dependent on wells, the water in which is satisfactory, and includes some 24 houses in Hoobrook, all of which have wells fitted with pumps.

A boring at Stone Manor, in 1926, was 86 ft. deep in sandstone, with a marly bed at the bottom. Water was struck at 70 ft., and stands at 47 ft. down.[2]

Stanklin Pool, covering an area of some acres, lies on the Upper Mottled Sandstone about ¼ mile west of the church. It is shallow (2 to 10 ft. deep), but is fed by two or three bottom springs situated at the west side, and there is a constant outflow carried off from the N.W. angle by a 2-in. pipe. The bog at the southern end receives the drainage of a small pool, which lies about 100 yds. up the valley and is much contaminated by house drainage.[3]

Stoulton.—Maps : 199 ; 54 S.W. ; 34 S.W., S.E. 41 N.W., N.E.

Mostly on Lower Lias ; a small portion in the hollow between Muckenhill and Lower Wolverton is on Rhaetic and Keuper Marl. Locally there is superficial sand and gravel (Drift).

The parish is dependent on wells and rain-water storage ; but while the supply in the majority of the wells is adequate, in many cases it is contaminated. According to Dr. G. H. Fosbroke,[4] there are draw-wells at Low Hill—one deep—and there does not appear to be any scarcity of water ; the water in two wells at Egdon Lane supplying 4 cottages is said to smell of sulphuretted hydrogen, so that recourse to an adjacent well is necessary ; one well at Windmill Hill is supplied by a ditch ; and at Haw Bridge 5 cottages are supplied by a shallow road-side draw-well, while two other houses use a very shallow well fed by a ditch. 19.4 per cent. of the samples taken were reported 'fit for drinking purposes.'

Suckley.—Maps : 199 ; 55 S.E. ; 32 (4 qrs.), 39 N.W., N.E.

The larger western portion of Suckley parish is on the lowest beds of the Old Red Sandstone, the remainder on the Suckley Hills which are composed of Silurian strata, from the Upper Ludlow Shales down to the May Hill Sand-

[1] An old shaft proved 460 ft. of Marl without reaching the base (Murchison, 'Silurian System,' 1839, p. 31) ; 800 ft. have been proved since (p. 24 above). For details of No. 3 boring at Stoke Prior, and further information about the salt deposits, see Dr. R. L. Sherlock, 'Special Reports Mineral Resources Gt. Brit.,' vol. xviii (*Mem. Geol. Surv.*), 1921, pp. 89, 92, 93.

[2] Communicated by E. Stanley Hall, F.R.I.B.A.

[3] For further particulars see *Trans. Worcs. Nat. Club*, vol. vii, pt. 4, 1921, pp. 316–318.

[4] Report on the Water Supplies . . . Pershore Rural District, *op. cit.*, 9101, pp. 23, 24.

stone (near The Beck). The Silurian limestones give rise to bold ridges, the shales to valleys. Springs are few, mostly in the valleys, and mainly the product of surface drainage.

The Rectory and Lower Court Farm have private piped supplies from springs ; several springs around Tunbridge are used by people in the vicinity ; but otherwise the parish is dependent on wells.

Strensham.—Maps : 199, 216 ; 44 ; 48 N.W., S.W.

On Lower Lias, with local surface deposits of sand and gravel ; a small area in the extreme west is on Rhaetic and Keuper Marl.

The Court and two standpipes in the village are supplied from a borehole (see below). Otherwise the parish is dependent on shallow wells, one or two of which are fed with water collected by pipes from certain small springs.

In 1910 Dr. G. H. Fosbroke reported that at Upper Strensham the supply was generally sufficient and that several houses used ' Hamlet's Well.' Of well-waters analysed 24 per cent. were certified fit for drinking purposes and 72 per cent. (including ' Hamlet's Well ') as unfit or contaminated.[1] Considerable trouble has been experienced from the presence of sulphuretted hydrogen ; wells having this defect have to be left uncovered to allow the gas to pass off.

STRENSHAM COURT BOREHOLE

About 200 yds. from road from Pershore to Twining and Tewkesbury, and opposite end of stables, Strensham Court. Particulars communicated by H. L. Burt, Sanitary Inspector, Pershore R.D.C.

Borehole (small diameter) :—

[Gravel of river terrace		? 42 ft.[2]	246 ft.
Lower Lias. Blue clay	...	...	
Rhaetic ...	...	...	
Keuper { Tea-green Marls	...	...	
Red Marls : entered]	...		

Water raised by Duplex pump driven by a Tangye oil engine to a concrete tank (14 ft. × 9 ft. × 4 ft.) on the roof of the Court, from which the Court and two stand-pipes in the village are supplied. (Analyses Nos. 520–522, p. 172).

The undertaking belongs to the Trustees of the late John Taylor.

Mr. Burt says " There is a heap of red marl on the site, said to have been taken out from the borehole."

Teddington.—Maps : 216, 217 ; 44 ; 55 N.E., S.E.

On Lower Lias, except for a small tract on the Middle Lias (Sandy Beds succeeded by Marlstone) on Oxenton Hill in the south.

Water is laid on to the majority of the houses, and to a tap in the village from a supply installed by the late Sir Richard Bidulph Martin, now the property of Mr. Attwood. It has its source in springs issuing from the base of the Sandy Beds up the valley between Oxenton Hill and its higher neighbour The Knolls, ⅝ mile S. by E. of the church. The water is tapped at its outbreak and piped to a reservoir (6,500 gallons) in a field some distance below whence it gravitates to the village. Some 1,200 gallons is the average daily quantity, but economy in its use has to be exercised at times.

Tenbury.—Maps : 181 ; 55 N.W., N.E. ; 18 N.E., S.E., 19 (4 qrs.).

A considerable parish on the right or south bank of the River Teme, lying for the most part on Old Red Sandstone (mainly marls) below the horizon of the Birch Hill Limestone, which crop out, for example, at Haws Hill and Hill Top. Locally, on the surface of the Old Red are little patches of gravel : one of these, a portion of an old river terrace composed of Old Red Sandstone and Silurian materials, is excellently exposed in a gravel-pit (354.3 ft. above O.D.) on the Worcester Road, about a mile east of Tenbury Wells.

[1] ' Reports on the Water Supplies . . . in the Pershore Rural District,' *op. cit.*, p. 38.
[2] Tomlinson, M.E., *Quart. Journ. Geol. Soc.*, vol. lxxxi, 1925, p. 140.

St. Michael's College has a piped supply from a private reservoir at Raddlebank—a mile and a quarter distant in a south-westerly direction—where two springs issue from the neighbourhood of the Birch Hill Limestone. Pool House Farm is supplied by gravitation from a spring issuing at 475 ft. O.D. from the Birch Hill Limestone of Hawes Hill.

Tenbury Wells

Tenbury Wells (population 1,922) spreads over Old Red Sandstone, gravel and alluvium ; but the greater part of the town proper is on gravel. The general level of the town is from 174 to 180 ft. above O.D. The portion between the River Teme and Kyre Brook is liable to flood : in May, 1886 the river rose rapidly and an old man was drowned in his cottage near the church ; on December 3rd and 4th, 1910, flood-water extended far up Teme Street.

On the representation of the County Council as to the polluted state of the water-supply the Local Government Board sent Dr. H. Airy to hold an Inquiry. In summary, his report was :—" Town liable to be flooded from River Teme. Sewers liable to regurgitation in time of flood ; discharge direct into River Teme. Water from wells, mostly shallow, sunk in porous gravel bed, polluted by leakage from cess-pits. Need of scavenging by Sanitary Authority. Dr. Frankland's analysis of Tenbury water.—' Simply sewage which has soaked through a few feet of porous soil.' " [1]

Steps were then taken, and W. Wyatt, of Shrewsbury, reported to the Tenbury Authority on 9th May, 1894, on the sources of supply within an area of about 30 sq. miles. Within 3 or 4 miles of Tenbury he found that the hardness of the water was 16 to 17 degrees and remarked that this, though not excessive, was sufficiently high to make softer water desirable. It was suggested to him that a source on the north or Shropshire side of the river would be advantageous, so that water from the Birmingham Corporation's aqueduct (which now passes within 4 miles of Tenbury) could be laid on if ever found necessary. No source much below the 400-ft. contour-line would properly supply the town by gravitation and Wyatt concluded that the only available sources were :—

South of the River Teme		
1.	Sunny Bank Dingle	about 3 miles
2.	Cadmore Brook at Birchley ...	,, 2½ ,,
3.	Brinsell Dingle, Hanley Child	,, 3 ,,
North of the River Teme		
4.	Cornbrook	,, 2½ ,,
5.	Brook at Gotmore	,, 2½ ,,
6.	Brook at Weston	,, 2½ ,,

none of the three first being in any way preferable to those on the north.

No. 4, in order to get sufficient height, would require impounding at or above Whatmore Mill and was regarded as unsuitable because the water came mainly from coal-pits then at work and was very foul where it reached the brook. No. 5, at the necessary height, was almost too small to be worth consideration. " No. 6 is a site that might be accepted if nothing better could be found. The watershed is sufficient and there is a good place for a dam at a moderate cost."

Other sources mentioned, but not recommended, were a well or wells in the Teme valley at a distance above the town, and the river itself. Sources 1 to 6 were all more or less open to objection because the watersheds were composed almost entirely of highly cultivated land—the least objectionable in this respect being No. 6.

" Going further north the geological condition of the surface changes completely and there is a corresponding change in the character of the water. At Clee Hill it is much softer than immediately round Tenbury, but in some instances it contains a considerable quantity of iron. That however by itself

[1] 23rd *Ann. Rep. Local Gov. Bd.*, Suppl. for 1893–94 (1894), pp. 42, 43.

cannot be looked upon as an important objection because the iron is very easily got rid of by aeration and filtration and it is well known that the presence of iron assists to some extent by its deposition in the removal of other impurities.

" There are four mine levels or adits . . . draining disused mines at Clee Hill, some of the mines exhausted and others not completely so :

No. 1. Whitton Court.
,, 2. Knowbury—about ½ mile from the church.
,, 3. Near the Angel—Ludlow and Clee Hill Road.
,, 4. Near Gorstley Rough—South of Caynham Road.

" Large quantities of water which I believe to be of excellent quality are discharged from these levels. No. 1 is highly charged with iron. No. 3 does not appear to have any and the other two a moderate quantity.

" No. 4 is in my opinion thoroughly suited for the supply of Tenbury and second only to the Knowle water [see below]. I have it on good authority that the pits from which it runs are completely exhausted so that there would be no chance of contamination or loss of the supply by re-opening of the pits. This water is moderately soft and has not much iron in it. It would require filtration but after that process it would be perfectly clear and all traces of iron lost. . . .

" I now come to what I consider the best source that can be found within a reasonable distance—at a place near Knowle named on the ordnance maps ' Little Isle.' [1] . . . There are at this spot several springs yielding in the aggregate a large quantity of water. It is soft and free from iron, requiring no filtration. A sample has been submitted to Dr. Thursfield . . . he says it is excellent water in fact water of extraordinary purity. . . .

" The water [at ' Little Isle '] rises at several places in the little valley at various levels and judging from the fact that springs are everywhere low at the present time there is no reason to anticipate any failure of the supply. . . ."

Wyatt pointed out that the Elan Aqueduct of the Birmingham Corporation would come a quarter of a mile to the north of the ' Little Isle ' site and that its construction might disturb the ' Little Isle ' springs, but remarked that as " . . . all our work as far as Knowlgate will serve equally well for a supply from—1st the springs named, 2nd the mine level No. 4, which may be safely assumed to be beyond the reach of the Birmingham works, or 3rd from the Birmingham aqueduct by a mere extension of the piping to meet either case I consider I am fully justified in advising that the remote chance of disturbance alluded to should not be allowed to influence your choice. . . .

" The water [at ' Little Isle '] rises from a conglomerate similar to that found on the south-eastern slope of Clee Hill and it is not unlikely that it may be brought by a fault or underground passage from that slope."

Mr. Wyatt's ' Little Isle ' scheme was adopted and completed in 1895. The three springs at ' Little Isle ' were on the surface and came from the so-called Millstone Grit,[2] but wells—about 12 ft. deep—were sunk and covered over. From these the water gravitated to a service reservoir (90,000 gallons) at Rugpits or Hopesmoor a mile to the north of Tenbury.

In 1901, when the Elan Aqueduct was constructed, Mr. Wyatt's fear materialized : the ' Little Isle ' springs suddenly failed. The Birmingham Corporation offered to make good from their aqueduct the water lost, but the Rural District Council preferred to be independent. The Corporation accordingly laid a 9-in. pipe beneath their aqueduct in the Studley Tunnel and conveyed the intercepted water to a spot, beside a streamlet, three-eighths of a mile east of Studley Lime Works. Here there is first an inspection or intake tank and near by an aerating chamber, for the water is slightly irony.

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[1] ' Little Isle ' is on the line of the streamlet between Studley Lime Works and Knowle Hill, the southernmost spur of the Clee Hills.

[2] Cornbrook Sandstone, since shown to be of Upper Avonian (Carboniferous Limestone) age (E. E. L. Dixon, *Trans. Roy. Soc. Edin.*, vol. li, 1917, p. 1065).

From this chamber the water is conducted through a 5-in pipe to join up with the Council's pipe from ' Little Isle ' at a point between Nash Church and Court of Hill.

The altitude of the aerating chamber is about 670 ft. above O.D. and that of the surface of the water in the service reservoir about 370 ft. The pressure in Tenbury town varies from 65 to 95 lbs. according to position.

Parts of the Shropshire parishes of Burford and Nash (Burford Rural District) are supplied from the Tenbury scheme. The average daily quantity of water obtained is 50,000 gallons. (Analyses 534–536, below).

Tenbury Mineral Waters

Dr. A. W. Davis stated in 1847 [1] that " the well in the Crow Orchard [at the present Spa] is not the first by several that have been discovered at Tenbury all of the same character ; but none that had been previously found and examined contained iron. It appears that many years ago, an inhabitant of the town having occasion to sink a well on his premises, found the water so unfit for use that he filled the well up again. This was at some distance from the present Well. . . ."

The waters that obtained fame for the little town were discovered accidentally in 1839 when S. Holmes Godson was having a well sunk for household supply. Dr. Davis says that " two other wells were sunk near the first, the most distant not further than forty yards from it, and water similar in taste and obvious qualities were found, though no analysis of either was made."

Godson's well is situate beneath the harness room of the present stables of the Court. A small red-brick Bath-house was erected near the well. These Baths are still standing : they face on to the stable-yard. The plunge baths are still in position, but the building is now used for storing fruit.

According to Dr. A. B. Granville, who visited the locality shortly after the waters were discovered,[2] a shaft 30 ft. deep was sunk, 3 ft. in diameter ; it was lined with bricks down to the water's edge, and the water was ascertained to be 6 ft. deep. The rocks penetrated were :—

Strong gravel (freshwater spring beds)	
Blue marl : somewhat more than 10 ft....	
Hard blue limestone (dipping from S.E. to N.W.)	
Red marl conglomerate	30 ft.
Close or compact cornstone	
Other beds of Old Red Sandstone, through some fissure in which the mineral water probably springs ...	

Granville states that the water was analysed by both Prof. Brand and Prof. Daubeny, but as these authorities differed he prevailed upon Holmes Godson to get Mr. West of Leeds to examine the water on the spot and make an analysis (see p. 206). This was done and West discovered what the two Professors had not—although Prof. Daubeny found it independently shortly after in another sample that was sent him—" a portion of iodine (1/19th of a grain)."

Prof. Daubeny communicated the results of his (second) analysis to the Ashmolean Society of Oxford.[3] It is reported that he " found the water to belong to a class of mineral springs of rather unfrequent occurrence, containing common salt, united with a considerable proportion of muriate of lime, and a little muriate of magnesia, but scarcely a trace of sulphates of soda or of magnesia. . . . Professor Daubeny, however, discovered two other ingredients in the spring, which may perhaps assist in communicating to it peculiar virtues : these are iodine and bromine ; the amount of the former was

[1] ' An Essay on the Nature and Properties of the Tenbury Mineral Water,' London. (Printed by T. Benbow, Presteign). 1847. Pp. 1–40.
[2] ' The Spas of England—Midland Spas,' 1841, pp. 158–168.
[3] *Proc. Ashmolean Soc., Oxon.* for 1840 (1841), pp. 16, 17.

too minute to be appreciable, but that of the bromine was no less than 2.60 grains to the gallon." Regarding his analysis (see p. 206) he stated that " the proportion of bromine was greater with reference to the other ingredients than in any mineral water in which Prof. Daubeny had detected it, excepting that of Ashby de la Zouche, where it amounted to 4.68 grains to the gallon."

After the discovery of the mineral water in Godson's well it was sought at the Swan Hotel and found at a depth of 72 ft., but it was not analysed and no use was made of it.

Visitors to the Baths causing annoyance to the owner of the Court, he had another well sunk in the Crow Orchard. Saline waters were encountered, so a Pump Room and Baths—the present Spa—were erected. The well was sunk in the summer of 1846 and is located under the tower of the Spa. Dr. Davis records that the well was 47 ft. deep and gives the following particulars of the strata—noted by Richard Gibbs of the Geological Survey—passed through by the well :—

" Alluvium drift	10 feet
Red and green argillaceous spotted marls	30 ,,
Finely laminated, hard, red and green, micaceous, quartzose sandstone ...	5 ,,
Whitish-grey, very micaceous sandstone	2 ,,

The Manager of the Tenbury Baths Company, however, tells me that he has been down the well and that it is 89 ft. 3 in. deep—the first 40 ft. in ' marl,' the rest in ' rock.' [1]

D. Campbell of London University made an analysis of the water from the Crow Orchard Well in October, 1846 (p. 206, No. 657).

The mineral waters were neglected for many years, but on the property coming to the present owner a company—The Tenbury Baths Co., Ltd.—was formed in 1911 and improvements were effected.

Throckmorton.—Maps : 200 ; 54 S.W. ; 34 S.E., 35 S.W., 41 N.E., 42 N.W.

Mostly on Lower Lias with, locally, superficial sand and gravel ; a small part in the extreme east is on Keuper Marl faulted against the Lias.

The village, on clay, depends on some four of five wells (from 60 to 70 ft. deep) and on an undertaking (provided by Sir N. W. G. Throckmorton) supplied from a well situate about 100 yds. east of the church ; the water is raised to a tank and is laid on to a few houses. The average daily quantity got from this undertaking is 150 gallons, and a further 100 gallons per day could be obtained.[2] The water in one of the wells in the village is saline. Shortage has been experienced on several occasions of late years and the supply in part of this little parish is very poor. A ram forces water from the Piddle Brook to Tilesford Farm for the usual farm purposes.

Tibberton.—Maps : 199 ; 54 S.W. ; 29 S.W., 34 N.W.

This parish is on Keuper Marl. The Arden Sandstone crops out in the west, and dips E.N.E. below the Marl on which the village is situate. Farther south, in the parishes of Spetchley and Norton, it is a useful source of water.

The parish is dependent on wells. The supply of water appears to be adequate, but there is local pollution.

Tidmington.—Maps : 201, 217, 218 ; 44 ; 51 S.E., 58 N.E.

A small ' detached ' parish on Lower Lias clay, and dependent on wells.

[1] In answer to my enquiry W. Wickham King calculated that the Tenbury well " struck the Holdgate Sandstone [see p. 17] 900 ft. above the Ludlow Bone Bed [top of Upper Ludlow Shales, p. 14] and below which [Holdgate Sandstone] I know salt-waters do occur." The calculation is based on heights (1) of the Birch Hill Limestone outcrops at Hawes Hill and Birchley Bank to the south of Tenbury, (2) of the Ludlow Bone Bed outcrop at Caynham, 4 m. to N.W., and (3) of the bottom of the well taken as about 90 ft. above O.D.

[2] ' Return as to Undertakings in England and Wales ' (*Local Gov. Bd.*), 1915, p. 341.

Tredington.—Maps : 200, 201 ; 44, 54 S.E. ; 44 S.E., 45 S.W., 51 N.E., S.E., 52 N.W.

This ' detached ' parish is on Lower Lias, with patches of gravelly ' Northern Drift.' In the north the Lower Lias is not thick : White Lias has been worked beneath it at Newbold Lime-kiln.

Tredington village and the hamlets of Darlingscott, Blackwell, Armscott and Newbold-on-Stour are supplied from wells many of which are shallow and the supply from which is locally inadequate. At Blackwell there is a public well near the pool and at Armscott a public pump.

BORING AT THE POOL HOUSE, ARMSCOTT[1]

A boring was made here in 1909 to a depth of 359½ ft. by a contractor acting for a water diviner ; but as no water was then obtained it was continued by Messrs. C. Isler and Co., Ltd. until water overflowed at the surface.

No record was kept of the rocks bored through by the first contractor, but as Armscott is on a low zone of the Lower Lias—the true Rhaetic White Lias being exposed within a mile of the village—these strata must have been those indicated below. Messrs. Isler have supplied the details of the rocks below 359½ ft., additions being in parenthesis.[2]

		Thickness	Depth
		Ft.	Ft.
[Lower Lias, Rhaetic and Keuper Marl]		359½	359½
[Keuper Marl]	Hard red marl	53	412½
	Light rock	1½	414
	Hard dark rock	23	437
	Dark and light rock mixed	10	447
	Hard red marl	9	456
	Hard marl and rock mixed... ...	83	539
	Marl	97	636
	Marl and grey rock mixed	24	660
[Keuper Sandstone]	Sandstone	7	667

Tubes in borehole :—
430 ft. of 4-in. tubes, top 2 ft. below surface.
263 ft. of 2½-in. tubes, top 403 ft. below surface.

Tutnall and Cobley.—Maps : 183 ; 54 N.W. ; 16 S.W., S.E., 23 N.W., N.E.

This parish is on undulating ground. Roughly speaking, the eastern portion is on Keuper Marl, and most of the rest, including Tutnall, Tardebigge and Holyoaks, on Lower Keuper Sandstone with small tracts of Upper Mottled Sandstone and Pebble Beds in the north. There are the usual local patches of gravel and sand.

Tutnall, Tardebigge and certain other areas are supplied by the East Worcestershire W. Co., whose mains run along the road past Hewell Park to Headless Cross. Outlying houses are dependent on wells and a few springs. It is said that before pumping was commenced by the Company the wells at Tardebigge, and in the sandstone country generally, yielded adequate supplies of, usually, good water, but that subsequently the supplies were much depleted—presumably by the lowering of the water-table. A fault running from near Barnt Green to Hewell Grange throws the Keuper Marl against the sandstones. In Hewell Park several springs issue at or near the fault line and discharge into the lake. Water from the lake is pumped up to the water-tower in the Park close to the side of the Bromsgrove–Redditch road for use in case of fire.

Birchensale is supplied by ram with water for farm purposes from a neighbouring artificial stream, made in the past for a mill.

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[1] Richardson, L., in *Trans. Worcs. Nat. Club*, vol. vii, pt, iv, 1921, pp. 337–339.

[2] Compare the boring at Lower Lemington, about 6½ miles to S. by W., of which an abstract is given on page 1.

Upper Arley.—Maps : 167, 182 ; 55 N.E., 61 S.E. ; 3A S.E., 3 S.W., 7 N.E., S.E., 8 N.W.

Lying athwart the Severn, this parish is mainly on Coal Measures ; Enville Beds rest on these in the north and Old Red Sandstone rises from beneath at Shatterford. Valley gravels occur near Arley Station (at 160 ft. above O.D.) ; west of the church ; in Arley Park ; and at the Home Farm, Arley.

The village is on Coal Measures. Parts of it are supplied by a good spring near the church, by a public pump (over a well said to be about 40 ft. deep) in the village, and by private wells. The majority of the last are fitted with pumps, but a few—as at The Forge (30 ft. deep with 7 ft. of water in it on 24th July, 1923)—are draw wells.

Arley Castle.—A supply of about 4,000 gallons per day is collected from springs below and near the Castle and pumped by ram up to a tank on the roof of the house, the overflow supplying the gardens, etc. The ram is worked by brook water. D. Llewellyn, Sanitary Inspector to the Kidderminster R.D.C., informs me that in times of shortage water is pumped from a well in the Arboretum into a tank in the cellar of the Castle and thence raised by hand-pump to the tank on the roof.

H. Tayleur informs me that Bromley Farm, Piggots, Hoxton's Farm and Cottages are supplied by windmill from a well near the River Severn. There are three storage tanks on the rising main, holding in all about 7,000 gallons.

Hillfields House is supplied from a well 40 ft. deep in which, in July, 1923, water stood at 30 ft. from the surface. Formerly water was pumped up to the house by ram, but this source of supply has been discontinued.

The remainder of the parish is dependent on wells and springs : the Shatterford district, which is laden with water, chiefly on springs ; one in particular, in a field on the north side of the road, some 300 yds. on the way to Kidderminster, issues from the Old Red Sandstone, and is largely resorted to. Acute shortage of water is nevertheless experienced at times on various properties at Shatterford. A shaft was being sunk in July, 1923, on the site of the coal mine worked many years ago [1] and from it an ample supply of water—said to be fit for drinking—was being pumped up and utilised by some of the cottagers near by for domestic purposes.

'Stinking Ditch.'—This is a spring, caught in a bricked dip, situate 1¼ miles S. by W. of Arley Castle or 400 yds. S.E. by S. of Cherryorchard Farm. It gives rise to a streamlet that flows between Cliff and Seckley Woods into the Severn near Seckley Cottage, and is so impregnated with sulphuretted hydrogen that it can be smelt a hundred yards away.[2]

Upton-on-Severn.—Maps : 199, 216 ; 43 N.E., 44 ; 47 (4 qrs.).

The country-town of Upton-on-Severn (population, 2,004) is built on a rise of sand and gravel (maximum elevation, 50 ft. above O.D.) environed by Alluvium and in times of flood by water. The flood-level of 1886 was 46.01 ft. above O.D. and at that time boats could reach the centre of the town. Near the railway station a great quantity of sand was drawn in the past by the railway company.

In 1906–12 the borehole described below was made with a view to supplying the town, but the expense incurred in sinking the borehole has prevented the laying of mains and the connecting up of the houses. All new houses have the water laid on : some thirty houses and the Union are at present supplied from the tank at the borehole. Otherwise the little town is dependent on wells the water in most of which rises and falls with the Severn and is unsatisfactory for drinking purposes.

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[1] A boring made at Shatterford between 1850 and 1860 proved 1,359 ft. of productive Coal Measures on 28 ft. of basalt. E. A. Newell Arber, *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, 1914, pp. 336, 337, 409, 410.

[2] Atkins, A. H., in *Midland Naturalist*, 1883, p. 33.

BORING AT RED HILL

Made 1906–12 by Messrs. E. Timmins and Sons, Limited, Runcorn. Surface-level.—160 ft. above O.D.

Condensed record [1] of strata :—

		Thickness Ft.	In.	Depth Ft.	In.
	Soil and gravel	2	0	2	0
[Keuper Marl]	Red marl	23	0	25	0
	Hard grey marlstone	21	0	46	0
	Red, grey, brown and blue marl with gypsum, some thin sandstones ...	1,283	0	1,329	0
[? Keuper Sandstone]	Grey and reddish-grey sandstones with bands of marl	35	9	1,364	9
[Keuper Sandstone]	Grey and reddish-grey sandstones with subordinate bands of shale, marl and conglomerate ...	335	3	1,700	0

Water-level.—On May 2nd, 1913, 36½ ft. below surface ; now overflows. During boring water was met at depths of 60 ft. and 190 ft., but at no other depth until the Keuper Sandstone was reached.

Yield.—April 18th to May 2nd, 1913, 330 actual pumping hours : 668,623 gallons (=2,026 gallons per hour). May 2nd to 15th, 1923, 12 hours daily, 163 actual pumping hours : 462,738 gallons (=2,838 gallons per hour). During 4½ hours of the pumping on May 2nd, the yield was at the rate of 2,291 gallons per hour.

The water overflows into a 10,000-gallon tank.

Quality.—See analyses Nos. 555–561.

Upton Snodsbury.—Maps : 199, 200 ; 54 S.W. ; 34 N.E., S.E.

On Lower Lias, with sporadic pebbles of quartzite (Drift) on the surface.

North of the Worcester road, near the ' Royal Oak,' a good ' spring ' of water, collected in the field to the north, discharges into a stone trough. It is the property of the Earl of Coventry who had a connection made and a brick structure fitted with a large tap erected for the use of the ' Royal Oak ' when brewing was done there. It is now used by the estate tenants free and by a few others for a nominal payment. A quantity of the water runs to waste.

Otherwise the parish is dependent on wells, some brackish and of poor quality, and there is occasional shortage.

Upton Warren.—Maps : 182 ; 54 N.W. ; 15 S.W., S.E., 22 N.W., N.E.

On the Keuper Marl. The East Worcestershire W. Co.'s water is laid on. The water in the wells formerly in use is said to have been good and sufficient.

Wardon.—Maps : 199 ; 54 S.W. ; 29 S.W., 33 N.E., 34 N.W.

On Keuper Marl, just below the Arden Sandstone. Two houses have Worcester City water laid on ; the others have wells in which the water is said to be sufficient and good.

Webheath.—Maps : 183 ; 54 N.W. ; 23 (4 qrs.).

This parish is for the most part on Keuper Marl, with local drift gravel. A small area running south from the neighbourhood of Hewell Lane, is on Lower Keuper Sandstone.

The village is supplied by the East Worcestershire W. Co., the outlying parts by wells.

[1] A full record of the strata passed through, and of the lining of the borehole, was given by the author in *Geol. Mag.*, vol. lx, 1923, pp. 119-121. The third item in the above abstract (marlstone, 21 ft. thick) possibly represents the Arden Sandstone.

Welland.—Maps : 199, 216 ; 43 N.E. ; 46 S.E., 47 N.W., S.W.

On Keuper Marl, with local gravel—as around Lumberton and Woodside Farms and the Pheasant Inn.

The scattered houses are dependent on wells.

Westwood.—Maps : 182 ; 54 N.W. ; 21 S.E., 22 S.W., 28 N.E., 29 N.W.

On Keuper Marl with patches of sand and gravel (Drift).

The few scattered houses are dependent on wells, some of which are fed with surface drainage. A dip-well at the lodge of Westwood Park, on the Droitwich–Ombersley road, appears to be so filled.

Westwood Park.—The drinking water for the mansion, a farm, and cottages near by, is obtained from a well beneath the mansion, the water being raised by electric pump. Water for other purposes for the mansion, gardens and farm, is raised by ram from the ' pool ' on the Marl north-west of the mansion. Herbert Bird tells me that this pool is supplied by a spring in a well reputed to be Roman, which gives 4,060 gallons per 24 hours.

White Ladies Aston.—Maps : 199 ; 54 S.W. ; 34 S.W., S.E.

This parish is on Lower Lias clay with traces of superficial gravel, except for a very small tract at Sneachill which is on Rhaetic and Keuper Marl.

The parish is dependent on wells, the supply in which is—speaking generally—not satisfactory.

Whittington.—Maps : 199 ; 54 S.W. ; 33 N.E., S.E., 34 N.W., S.W.

On the Keuper Marl with traces of gravel on the surface.

The village, on the Worcester–Pershore road, is supplied from the Worcester City Waterworks ; otherwise the parish is dependent on wells.

Wichenford.—Maps : 182, 199 ; 55 S.E. ; 27 N.E., S.E., 28 N.W., S.W., 33 N.W.

This considerable parish lies mainly on a flat stretch of Keuper Marl. It is dependent on wells of no great depth.

T. Chas. Jones-Williams informs me that the Laugherne Hill water supply is raised by pumps operated by a water-wheel situate between Peg Bridge and the point where the road crosses the Laugherne Brook by Laugherne Hill.

Wick.—Maps : 199, 200 ; 44, 54 S.W. ; 41 N.E., S.E., 42 S.W.

The parish is on Lower Lias clay, covered in the south locally by sand and gravel of a high river terrace and in the north by sand and gravel of a lower river terrace, and margining the River Avon, Alluvium. The boundary line between the gravel of the lower river-terrace and the bare Lias clay of the higher ground runs through the village.

The bulk of the drainage of the sand and gravel of the lower terrace, which amounts to little, is carried off into the Avon by a brooklet that flows westward to the south of Wick. At one place, namely near Cherry Orchard Barn, on the left bank of the Avon south of Wyre Mill, the sand-gravel bed reaches the river bank. Here there is a small area, close to the river, which is above the level of the ground liable to flood. A well sunk in the sand of this higher ground would collect only a very small quantity of water from the sand-bed and the clayey nature of the sand in the river bank is such that ready percolation from the river (when it was sufficiently full) to the well could not be expected. Without trial borings it cannot be stated whether the surface beneath the sand rises away from the river (although it probably does) or to what depth the sand goes below the normal level of the water in the river ; but even if the sand does go some feet below water level, owing to the very clayey nature of the river bed ready percolation into the sand-bed could not be expected.

The parish is dependent on wells. There is no scarcity of water, but only 25 per cent of the samples once taken were found fit for drinking purposes.[1]

Wickhamford.—Maps : 200 ; 44 ; 49 N.E., S.E., 50 N.W., S.W.

This parish on the Lower Lias clay has the Evesham and Pebworth Joint W. Co. supply, laid on to practically all the houses.

Wolverley.—Maps : 167, 182 ; 54 N.W., 55 N.E., 61 S.E., 62 S.W. ; 3 S.W., S.E., 8 (4 qrs.).

Except for a small area of Old Red Sandstone and Coal Measures in the extreme north-west, this large parish is on Bunter rocks—Lower Mottled Sandstone, Pebble Beds, and Upper Mottled Sandstone—with a prevalent south-easterly dip, but affected by faults east of Lea Castle.

The upper beds of the Lower Mottled Sandstone and the base of the Pebble Beds form an escarpment at Horsley Bank and Blakeshall Common (the southerly continuation of Kinver Edge, Staffs.). Such of the rainfall as does not sink into the porous Lower Mottled Sandstone of the fine collecting ground situate between this escarpment and the Palaeozoic rocks in the west is carried off south-eastwards by the Kingsford Brook, *via* Drakelow, along a valley cut through the escarpment.

Wolverley House, Manor House and five cottages are supplied from Old Forge (see below) ; Rock Mount, Bouchers Cottages and the Schools from a private main conveying Kidderminster Corporation water ; and the occupants of five houses at Longbridge use the public pump by the roadside ; otherwise Wolverley and Cookley are supplied from the Council's waterworks near the bridge at Cookley Forges.

Solcum Lane Spring.—This is a public spring (thrown out at the base of the Pebble Beds by a marly layer) situate between Blakeshall and Knowles Farm. A bricked catch-pit, with a lid, has been provided by the Council to supply the inhabitants of Solcum Farm, and those dwelling near Baxter's Monument, with drinking water. Lower down is an open drinking place for cattle. The spring is perennial and the water slightly chalybeate.

Blakeshall is supplied from a well some fifty feet deep in the Pebble Beds in which the water was standing at 35 to 40 ft. ex surface in July, 1923. Formerly the water was raised by wind-power but now by a petrol engine.

Cookley.—Three-eighths of a mile north-west by north of Cookley Church a spring issuing from the Pebble Beds at the side of the lane to Wolverley, on the west side of the River Stour is conveyed by pipe to a ram—worked by river water—which forces it up to the works of the Steel Stampings Co., Ltd., Cookley Iron Works, and three adjacent cottages.

Hill House, situate about half a mile west-north-west of Wolverley, has water forced up by ram from the Kingsford Brook ; but obtains drinking water from the Elan Aqueduct (Birmingham Waterworks).

Lea Castle is supplied from a borehole, 180 ft. deep (160 ft. to water in July, 1923), through the basement-beds of the Upper Mottled Sandstone into the Pebble Beds.

Old Forge.—There is a well here in the Pebble Beds by the River Stour, which is liable to receive flood-water. Water is pumped by the water-wheel of the demolished mill to a reservoir at a higher level (to obtain pressure), whence it supplies Wolverley House, the Manor House, and some five cottages.

Castle Hill.—This house is supplied from a spring in a dell in the Coal Measures. The water is forced up by ram to the house and has now been laid on to the cottages to the east. These cottages are on the highest beds of the Trappoid Breccia, which consist here chiefly of marls containing gypsiferous bands, and had a well in them but the water was brackish and therefore its use was abandoned.

For Wolverley Waterworks, see Appendix, p. 215.

[1] Fosbroke, G. H., Reports on the Water Supplies . . . in the Pershore Rural District, *op. cit.*, p. 36.

Wribbenhall.—Maps : 167, 182 ; 55 N.E. ; 8 S.W., 14 N.W., S.W.

An important fault runs N. through the centre of Bewdley, passing west of Grey Green, and east of Warshill Camp. To the west are found Old Red Sandstone (in the north), Coal Measures, and " Permian " ; east of the fault Lower Mottled Sandstone, finely displayed in Blackstone Rock, forms most of the parish, the Bunter Pebble Beds coming on in the extreme south, near Mount Pleasant, and in a small tract in the north of the village. Alluvium margins the River Severn and has been worked for brickmaking south of Blackstone.

With the exception of its outlying parts, the parish is supplied from the Bewdley Waterworks, whose Pumping Station and Mount Pleasant reservoir are within its boundaries.

A spring issuing from the Old Red Sandstone a hundred yards north-east of Riddings Barn (1¼ miles N. by W. of Wribbenhall Church) is piped to a chamber near the barn, and thence to Crundalls Farm and Summerhill House.

Wyre Piddle.—Maps : 199, 200 ; 54 S.W. ; 41 N.E., S.E., 42 N.W., S.W.

On Lower Lias with a local capping of sand and gravel (see Fladbury, p. 54) and, down by the Avon, alluvium.

Most of the houses in the village are supplied by the Rural District Council from a spring issuing from the ' sand bed ' half a mile eastward of the church. The water is collected into tanks, pumped to a service reservoir on the embankment that carries the Evesham–Worcester road over the railway a little to the east of the village, and thence laid on to the majority of the houses.

Outlying parts of the parish, mostly on the bare Lower Lias, are dependent on wells, many slightly brackish.

Wythall.—Maps : 168, 183 ; 54 N.E. ; 10 S.E., 11 S.W., 16 N.E., 17 N.W.

Wythall parish (formerly part of King's Norton parish, the rest of which has been transferred to Warwickshire) is on the Upper Keuper Marl on the surface of which, locally, is gravel—Drift. It is dependent on wells, the sufficiency and quality of the water in which is described as ' fair.'

III.—LOCAL DETAILS AND CONDITIONS OF WATER SUPPLY—(*continued*)

B.—Urban Districts, Boroughs, and County Boroughs.

Bewdley.—Maps: 182; 55 N.E.; 7 S.E., 8 S.W., 13 N.E., S.E., 14 N.W.

This Borough is on Middle Coal Measures, but a large fault, running from the centre of the town towards Ribbesford Church, lets down Lower Mottled Sandstone, succeeded by Pebble Beds, on the east in the neighbourhood of Winterdyne.

Previous to 1902 the inhabitants had to depend on private wells and on six public wells, one of them situate in a meadow near Wribbenhall across the Severn. The amount of water available in the wells in Bewdley was inadequate, and its quality unsatisfactory, and the supplies were condemned by Dr. Theodore Thompson in his Report to the Local Government Board in 1897.[1]

Before 1902 some attempts had been made to provide a more satisfactory supply. Thus in 1885 a trial boring (p. 96) was made close to Town Mill House, Dowles Brook; and in May of that year the same engineer suggested sinking in the Lower Mottled Sandstone on the opposite side of the Severn (Butt Town Meadow, in Wribbenhall parish). This suggestion, and an idea then entertained of obtaining water from the Kidderminster Town Council's Waterworks, did not mature, and in October 1886 it was resolved to sink a trial well in Dog Lane Meadow. A. W. Humpherson, Waterworks Manager, Bewdley, informs me that other sinkings were made in Butt Town Meadow, Rock Coppice, and Park End Coppice. In May 1891 and 1892 resolutions were passed in favour of obtaining water from the Elan Aqueduct of the Birmingham Waterworks, and coupled with the 1892 resolution was an instruction that the Butt Town Meadow scheme should be carried out. Apparently the instruction was ignored, for in July, 1896 attention was again given to the Dog Lane Meadow sinking. Eventually a site at Blackstone, in Wribbenhall parish, was decided upon, and on 30th April 1902 the present Waterworks were opened.

Bewdley Waterworks

Supply Bewdley Borough (part); part of the parish of Wribbenhall (Kidderminster R.D.); and furnish a supply in bulk to Stourport U.D.C.

Source of Supply.—Two boreholes in Lower Mottled Sandstone close to the Severn at Blackstone, Wribbenhall. The second boring (1913) (193 ft. deep and 16 in. in diameter) was made by Messrs. A. C. Potter & Co., London. Although the borings are so close to the Severn the rest-level does not appear to be affected by the rise and fall of the river: there is no evidence from the chemical point of view that there is any connection between the river and well waters. The average daily quantity of water obtained is 170,000 gallons a day and a further 290,000 could be obtained. Surface-level, 76 ft., O.D.; rest-level, 8 ft. ex surface, dropping, when pumping is in progress, to 31 ft. ex surface.

Works.—There is no filtration. The service reservoirs are:—Low Level: Mount Pleasant, Wribbenhall parish (about half a mile south-east of the Pumping Station), 180,000 gallons; High Level: Long Bank, Bewdley (1⅔ miles W.S.W. of Bewdley town, close to the south side of the Cleobury Mortimer road), 60,000 gallons. Pressure is sufficient. The Pumping Station is at Blackstone.

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[1] 27th *Ann. Rep., Local Gov. Bd.*, Suppl. containing Report of the Medical Officer for 1897–98 (1898), pp. 108–117.

Quantity of Water supplied.—The daily average is 75,000 gallons and 95,000 gallons in bulk to Stourport. Supply is constant.

Quality of water.—Excellent. See analyses Nos. 63–71.

No houses in Bewdley town are supplied from public standposts : in all cases water is laid on to premises. Wribbenhall is supplied with Bewdley water. The Bewdley Waterworks commenced to supply Stourport (from the Mount Pleasant reservoir) in 1913, when ' for motives of economy,' Stourport gave up taking water from the Kidderminster Waterworks. It was to cope with this increased demand that the second borehole was put down, a few yards from the old one, and more powerful pumping plant—capable of lifting to the Mount Pleasant reservoir 20,000 gallons per hour—was laid down and brought into operation on October 31st, 1914.

Mr. Humpherson, to whom I am indebted for much of the above information, informs me that there are no useful springs running to waste in the Borough ; but that Park End Spring supplies five houses.

Borings near Dowles Brook, Forest of Wyre

1.—' *Town Mill* ' *Boring*

Between Town Mill House (close to and opposite the mill, which has been demolished, and about ½ mile above the main road) and the Old Manor House, Dowles, a bridge spans the Dowles Brook at Oak Cottage, which is on the north side of the Brook 250 yds. E. of the mill. On the south side of the brook, in the field between lane and brook, and close to the bridge, is a borehole. The top of the borehole is still visible, covered by a stone that can be easily moved, and the water in the borehole is known by the inhabitants of the neighbourhood to be ' very salty.'

A. H. Atkins says [1] that this ' boring for coal ' was made about 1878, was 1,200 ft. deep, that coal was found, but the result was unsatisfactory ; that water filled the borehole from below, and approached to near the surface, but was ' as salt as brine.' H. B. Woodward's reference to the boring [2] is known to be derived from Atkins' paper.

T. C. Cantrill informs me (*in litt.*, 7 Sept., 1923) :—" According to a section given me by the late Daniel Jones the boring was about 384 yards deep. The upper beds, down to 159 yds. 2 ft. 8 ins., were Coal Measures (there were no coals, only a few thin smuts and fireclays). The lower beds he thought were Old Red, as they were mostly chocolate, red and purple-coloured. In view of the late E. A. Newell Arber's conclusions in the case of Alton No. 1 [boring, see below], some of these lower beds may be red Coal Measures, although I doubt it. According to Jones the boring was certainly made for coal and the date was about 1875 ; a Mr. Brocklebank of Stockport was one of the promotors."

J. Steele Elliott, of the Old Manor House, Dowles, has a piece of the core in his possession : the borehole was about 4 in. in diameter.

The Coal Measures (probably Middle Coal Measures only [3]) in this neighbourhood rest directly on the Downtonian (Lower Old Red Sandstone). These Downtonian strata are productive of salt water—as at Saltwells, Dudley, and Tenbury Wells (p. 18)—and there is little doubt that the salt water in this borehole comes from the same source.

2.—' *Town Mill House* ' *Boring*

The site of this boring is 300 yds. due W. of the preceding, about 20 yds. east of the now demolished mill and between it and Dowles Brook. It was made in 1885 with the object of obtaining a supply for Bewdley, but the water proved unsatisfactory. John Eunson, C.E., of Northampton, was the engineer for the Council at the time, but Stanley Hemingway, Town Clerk, has been unable to trace any further information about it.

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[1] *Mid. Nat.*, vol. vi, 1883, p. 33.
[2] Victoria History of the Counties of England, Worcestershire, vol. i, 1910, p. 11.
[3] See E. A. Newell Arber, *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, 1914, p. 410.

3.—*' Coventry Mill ' Boring*

T. C. Cantrill informs me :—" This [Coventry Mill] is the name on the old 1-inch map (55 N.E.) ; on the 6-inch map it is ' Knowles Mill.' [1] No details were ever published, and the late Daniel Jones could obtain no section, but says it was 124 yds. deep. He has the following MS. note of information from one of the workmen :—' They passed through grey rocks, clunches and red marls, white and grey rocks, and one coal about 14 ins. thick towards the bottom. They also tapped salt water.' The boring was made for a Mr. Higginbotham of Pensax Court."

4.—*' Alton No. 1 ' Boring* [2]

The site of this boring is nearly a mile upstream from Knowles Mill, immediately south of the railway, and 140 yds. S.S.E. of the entry of the important tributary that joins Dowles Brook from the north-west, 2 miles above the main road from Bewdley to Kinlet.

The boring was made by the late Caleb Roberts of Brierley Hill in 1910. The late Daniel Jones—Mr. Cantrill informs me—was called in to advise when it had attained a depth of 1,112 ft., and " he appears to have seen the cores (and probably the site) and concluded that ' nearly the whole distance was in Old Red Sandstone '."

The late E. A. Newell Arber wrote [3] :—" This boring reached a depth of 1,102 ft. 8 in. By the kindness of Mr. C. W. Roberts, of Stourbridge, I have had an opportunity of examining the completed cores. They consist throughout of red or green or chocolate-coloured clays and marls, sometimes mottled, sometimes sandy, with occasional thin bands of typical ' Espley Green Grits.' Thin beds of grey, well-laminated shales, and of yellow or grey sandstones, and occasionally conglomerates also occur.

" From the shales I was able to obtain a number of plant remains. . . . These show that the rocks belong unmistakably to the Sweet Coal Series."

5.—*' Alton No. 2 ' Boring*

Of this boring Arber states [4] :—" Another and shorter boring (Alton No. 2) was put down at the same time [as Alton No. 1] in the Forest, about a mile South of Alton No. 1, but this penetrated for only a few hundred feet. The rocks, however, were precisely similar to those proved by Alton No. 1, and no coal was found in either boring."

6.—*Park House Boring*

This was situated immediately S. of Dowles Brook and 300 yds. N.E. by E. of Park House, i.e., about 700 yds. W. of Alton No. 1 boring and nearly a mile E. by N. of Wyre Forest railway station. It began with a 10½ in. chisel and was 805 ft. 9 in. deep. The late Daniel Jones thought it probable that everything below a depth of 59 ft. 8 in. belongs to the Old Red Sandstone.

Birmingham (part).—Maps : 168, 183 ; 54 N.W., N.E., 62 S.W., S.E. ; 5 S.W., S.E., 6 S.W., N.E., S.E., 10 (4 qrs.), 11 (4 qrs.), 16 N.W., N.E.

The County Borough of Greater Birmingham took in, in 1911, the parishes of Yardley, Northfield and Quinton, together with the greater part of the parish of King's Norton, all of which were previously in the administrative County of Worcester.

As the geology of most of this area is shown in detail on the recently published Geological Survey one-inch map Sheet 168 and six-inch maps, with accompanying memoir (pp. 207, 208), while the water supply of the whole

[1] 650 yds. W.N.W. of Town Mill.
[2] Called also " The Squash " or " The Squab " Boring.
[3] *Phil. Trans. Roy. Soc.*, ser. B, vol. 204, 1914, pp. 375, 376.
[4] *Ibid.*, p. 376.

city has been dealt with still more recently [1] it is unnecessary to enter into particulars here ; but it is desirable to emphasize certain points.

It will be observed that the district is traversed by the Birmingham Fault, by which the Keuper Marl on the east has been let down to a maximum depth of about 600 ft. against older rocks on the west. This Keuper Marl overlies Lower Keuper Sandstone, which comes to the surface between Northfield and Longbridge. To reach the Sandstone beneath the relatively impervious Marl, borings—up to 700 ft. in depth, according to position—are necessary. They have been made at several places—for example, at Messrs. Elliott's Metal Co., Ltd., Selly Oak ; Patent Enamel Co., Ltd., Selly Oak ; Hubert Road, Bournbrook, Selly Oak ; Selly Oak Baths, King's Heath Brewery (demolished), Corporation Baths, Moseley Road (just outside Worcestershire in Warwickshire)—but the trouble is that when the Lower Keuper Sandstone is reached its water is usually found too hard for boiler-feed, and incidentally expensive to pump, and in some cases the water from this deep-seated source has been abandoned in favour of town water. As regards water from the Marl, Louis Barrow, Works Engineer of Messrs. Cadbury Bros., Ltd., informs me :—" We have bored into Keuper Marl at various points, but not exceeding 80 ft. in depth, and have found the usual water associated with this, that is, heavily charged with salts and a certain amount of sulphuretted hydrogen."

On the other hand, to the west of the fault, are the richly water-bearing Pebble Beds, Upper Mottled Sandstone, and Lower Keuper Sandstone—not covered by Marl. These have the water impounded in them by the Upper Keuper Marl, which is let down against them on the east. Their contained water is drawn on by means of wells and borings at the Selly Oak Pumping Station of the Birmingham Corporation's Waterworks (now abandoned as a source of supply) ; the Birmingham Battery Co., Selly Oak ; Messrs. Cadbury Bros. at Weoley Park ; and at the Manor House, Northfield.

At Ley Hill, Northfield, is a small area of Trappoid Breccia which contains a useful, but limited, supply of water that is drawn on for the supply of the house ' Ley Hill.'

South-east of the Birmingham Fault the City boundary takes in a portion of the ' Lower ' Lickey Hills, which are mainly composed of Lickey Quartzite (Cambrian), flanked on the south-west by the Trappoid Breccia, and on the north-east by Upper Llandovery (Silurian), followed by Bunter Pebble Beds.

The 'Lower' Lickey Hills are now for the most part a public park belonging to the City of Birmingham and the main interest which attaches to them from the present standpoint is that in their vicinity are the sources of the Rivers Salwarpe and Arrow—tributaries of the Severn and Stratford Avon respectively, and of the Rea—a Trent-system stream.

As shown on the ' Drift ' edition of the one-inch geological map, Glacial Drift—composed of stiff red clay, sandy clay, gravel and loose ' sharp ' sand—is spread over the greater part of the district. Prof. W. S. Boulton remarks :—" Apart from a general but impersistent sheet of gravel and sand mounds and long ridges of gravel and sand, sometimes sixty or more feet in depth, overspread the Keuper Marls east of Birmingham, marking the best residential sites, as at Moseley." [2]

Sir John Robertson, late Medical Officer of Health for Birmingham, informs me that all the dwellings in Birmingham are supplied with town water except for a few isolated dwellings in the rural parts.

Birmingham Corporation Waterworks

The terminus of the Elan Aqueduct, 73 miles 2 furlongs 9 chains 20 yards long, bringing water from the Elan Valley which joins the River Wye near Rhayader, Central Wales, is in the Frankley Reservoir (100,583,132 gallons)—mainly in Frankley parish, partly within the Birmingham boundary.

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[1] ' Wells and Springs of Warwickshire ' (*Mem. Geol. Surv.*), 1928, pp. 150–174.
[2] *Engineer*, 1920, p. 646.

The Elan Valley Water Scheme was commenced in 1893 and water commenced flowing into the Frankley Reservoir on July 28th, 1904. The water is filtered at Frankley, was first brought into distribution in September, 1904 and the supply was laid on to the entire district in October, 1905, and subsequently to the Worcestershire parishes added in 1911 with the exception of a few dwellings in the rural parts. As the Welsh water is peaty in nature and possesses some slight power of corroding lead when allowed to stand overnight in lead service pipes, sodium silicate is introduced. From the filtered water tank (8,063,000 gallons : top water level 564 ft., O.D.) the water is distributed into the district of supply by means of one 42-in. gravitation main to the Low Level, two 43-in. gravitation mains to the Middle Level, and two 18-in. pumping mains to the High Level service reservoirs at Northfield (1,349,270 gallons : 710 ft., O.D.) and Warley (1,262,357 gallons : 773 ft., O.D.).

Two of the previous sources of supply of the Corporation's Waterworks were at Selly Oak and Longbridge. The well at the former locality is no longer a source of supply, but that at the latter (No. 1 below) is still used as a stand-by. The arrangement of the mains from the older wells does not permit of these waters being mixed with the Welsh supply, and it follows that, in times of pressure, when certain of the old sources are utilized, some districts receive a supply of water which is entirely Welsh, while in others the supply is entirely that from one or other of the wells or the Whitacre Pumping Station.

The average daily distribution in the three zones of supply for the year ending 31st March, 1923, was :—

Low Level	7.074	million gallons
Middle Level	10.343	,, ,,
High Level	6.635	,, ,,

The supply from Wales is now being augmented. J. H. Broadley, Secretary, Water Department, City of Birmingham, informs me [1] :—" Three sections of 60-inch main in reinforced concrete have been sanctioned on certain portions of the syphon sections of the Elan Aqueduct. The first section has been completed resulting in an additional supply of 200,000 gallons per day. The construction of the two further sections is progressing and when completed it is estimated that a total additional supply of 1¼ million gallons through the three sections will be obtained."

The statutory area of supply includes, in Worcestershire, the parishes of Wythall, Cofton Hackett (part) (Bromsgrove R.D.) ; Illey (part) (Halesowen R.D.). Illey (part) and Cofton Hackett (part) are now being supplied. Areas in Worcestershire, outside the statutory area now being supplied by agreement are—houses belonging to the Corporation in Frankley and in Alvechurch parishes, and houses near the Elan Aqueduct in Kidderminster Foreign and Wolverley.

Birmingham Wells and Boreholes

A table of data concerning 101 wells, mostly in the Birmingham area, some of them in the old Worcestershire portion, will be found in the Geological Survey memoir on Birmingham, and has been reproduced in that on Wells and Springs of Warwickshire (see Bibliography, p. 208).

In the following records, additional to or amplifying those of the table referred to above, the classification of strata is approximate only. The numbers in brackets after the title of bores refer to the corresponding numbers in that table.

1.—*Longbridge Pumping Station*

Particulars communicated by J. H. Broadley. Surface-level.—557.1 ft. above O.D.

[1] *In litt.*, July 30th, 1923.

	Thickness Ft.	Depth Ft.
Shaft (diameter 10 ft.) :—		
Sandrock ...	97	97
Borehole :—		
Sandrock ...	26	123
Marl	1¼	124¼
Sandrock ...	10	134¼
Marl	1	135¼
Sandrock ...	12	147¼
Marl	1	148¼
Sandrock ...	13	161¼
Parting in rock	½	161¾
Sandrock	5¼	167
Parting. (Much water)	½	167½
Sandrock	8	175½
Marl...	3	178½
Sandrock	40	218½
Marl...	2	220½
Sandrock	72	292½
Red marl	4	296½
Blue and black marl	4	300½
Light-coloured binds	6	306½

[Bunter from 0 to 296½ ft. ; below that depth, Coal Measures].

Yield.—500,000 gallons per day.

2.—*Messrs. Elliott's Metal Co., Ltd., Selly Oak* (65)

Finished on February 15th, 1906, and particulars communicated by Messrs. C. Isler & Co., Ltd. A section, differing in but a few unimportant details, is in the possession of the firm. Surface-level.—About 473 ft. above O.D.

	Thickness Ft.	Depth Ft.
Red clay	110	110
Rock and clay ...	13	123
Red clay	10	133
Rock and clay ...	45	178
'Granite' rock ...	3	181
Rock	18	199
Rock and marl ...	5	204
Rock and clay ...	8	212
Rock and Sandstone	18	230
Rock	16	246
Rock and clay ...	4	250
Marl and sandstone	4	254
Sandstone and clay	16	270
Clay	19	289
Sandstone ...	9	298
Clay	23½	321½
Rock and sand ...	3	324½
Rock limestone ...	2½	327
Clay	18½	345½
Rock	3½	349
Limestone and gypsum	2	351
Clay	2½	353½
Sandstone and marl	9	362½
Sandstone and clay	4	366½
Rock	8	374½
Sandstone	26½	401
Marl	5	406
Sandstone and clays	27	433
Clay	5½	438½
Sandstone and marl	9½	448
Sandy marl ...	3	451
Red sandstone ...	1	452
Red marl	28	480
Red sandy marl ...	4	484
Red marl	17½	501½
Red sandstone ...	6½	508
Blue marl	2½	510½
Sandy marl ...	9½	520
Red sandstone ...	8	528
Red marl	8	536
Red sandstone ...	1	537
Red and blue marl	7	544
Sandy marl ...	2½	546½
Sandstone	5	551½
Red marl	6	557½
Red Sandstone ...	3½	561
Red marl and rock	$0\frac{7}{12}$	$561\frac{7}{12}$
Blue marl ...	2⅙	563¾
Red and blue marl	1¾	565½
Blue marl and stone	¾	566¼
Red marl and a little stone mixed ...	15¾	582
Sandstone	10	592
Red marl	14	606
Conglomerate ...	4	610
Marl...	6	616
Mixture marl and rock	5	621
Conglomerate ...	4	625
Sand rock	$17\frac{5}{12}$	$642\frac{5}{12}$
Marl...	3	$645\frac{5}{12}$
Sandstone	$10\frac{1}{12}$	655½
Soft sandy marl ...	1¾	657¼
Soft sand rock ...	$9\frac{1}{12}$	$666\frac{1}{3}$

	Thickness Ft.	Depth Ft.
Marl	4⅓	670⅔
Sand rock	8⅓	679
Extra hard sand rock	4¼	683¼

	Thickness Ft.	Depth Ft.
Marl	4	687¼
Soft sand rock ...	9¾	697
Clay	3⅙	700⅙
Sand rock	3½	703⅔

[Keuper Marl to 374½ ft.; Lower Keuper Sandstone to 624 ft.; Bunter to base. In table of Birmingham wells referred to on p. 99 the classification is :—Keuper Marl to 366½ ft., with a doubtful thickness of drift; Lower Keuper Sandstone to base; and the record is regarded as doubtful].

40 ft. of 11½-in. tubes, top 14 ft. 6 in below surface.
490 ft. of 8½-in. ,, ,, 10 ft. 2 in. ,, ,, —the lower 350 ft. perforated.

Rest-level.—Standing 82 ft. ex surface. Supply.—9,000 gallons per hour. The use of this source of supply has been abandoned in favour of town water as the water obtained was too hard and expensive to pump.

3.—*Boring at Patent Enamel Co., Ltd., Selly Oak*

Made in 1910 and particulars communicated by H. Chesterman, Wye Bridge, Hereford.

		Thickness Ft.	Depth Ft.
[Glacial Drift and Upper Keuper Marls]	1. Loam and clay	8	8
	2. Fine silvery running sand ...	40	48
	3. Sandy clay and small beds of rock about 8 in. thick ...	200	248

Rest-level.—24 ft. ex surface. Supply.—40,000 gallons per day.

4.—*Thos. Fernihough's Dairy, 113A Hubert Road, Bournbrook, Selly Oak* (66)

Made in 1915 and particulars communicated by Messrs. C. Isler & Co., Ltd. Surface-level.—About 430 ft. above O.D.

	Thickness Ft.	Depth Ft.
Made ground ...	2	2
Black mould ...	1½	3½
Red clay and stones	28½	32
Hard red marl and stones	126	158
Hard red and blue marl with layers of gypsum ...	125	283
Hard red marl ...	14	297
Grey sandstone ...	12	309
Red marl	15	324
Red marl with layers of sandstone ...	8	332
Conglomerate ...	3	335
Red marl	2½	337½

	Thickness Ft.	Depth Ft.
Grey and red sandstone	2½	340
Red marl	6½	346½
Red sandstone ...	6½	353
Red sandstone with layers of red marl	13½	366½
Red sandstone ...	9	375½
Red sandstone with layers of red marl	12½	388
Red sandstone ...	57	445
Grey sandstone and blue marl ...	4	449
Red sandstone with marl layers ...	21	470
Red marl	10	480
Red sandstone ...	10	490

[Made Ground and Drift to 32 ft.; Keuper Marl to base. In the table referred to on p. 99 the strata below about 388 ft. are regarded as possibly Lower Keuper Sandstone].

Lined with 40 ft. of 9½-in. tubes, top 1 ft. 6 in. below surface.
166 ft. 4 in. of 6-in. ,, ,, level.

Rest-level.—Standing 70 ft., pumping 158 ft., ex surface. Supply.—2,280 gallons per hour.

5.—*Components Ltd., Bournbrook*

Made in 1916 by Messrs. R. N. Mouzer & Son., 172 Garrison Lane, Birmingham. Particulars communicated by Components Ltd.

Site of borehole.—Dale Road, Bournbrook.

Depth of borehole.—300 ft. : diameter.—4 in.

Rock penetrated.—Mostly sandstone [Upper Mottled Sandstone].

Water-level.—When not pumping the water comes to the surface : when pumping water falls to 17 ft. ex surface. Supply.—Approximately 4,000 gallons per hour.

6.—*Selly Oak Baths, Tiverton Road* (67)

In engine-room. Surface-level.—430 ft. above O.D.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Keuper Marl]	Loam...	1	6	1	6
	Marl	110	5	111	11
	Blue shale		1	112	0
	Marl	38	0	150	0
	Boulder stone	1	0	151	0
	Gypsum and shale	1	0	152	0
	Marl	48	0	200	0
	Thin vein of white rock	—	—	—	—
	Marl	100	0	300	0
	Slight indication of sand	—	—	—	—
	Marl	140	0	440	0
	Marl and sandy rock	10	0	450	0

[In the table referred to on p. 99 the first item is regarded as possibly drift, and the last as Lower Keuper Sandstone].

Water-level.—Standing 34 ft. ex surface.

Supply.—80,000–90,000 gallons per 24 hours.

7.—*King's Heath Brewery* (64)

Made for Messrs. Bates in 1885-86 by Messrs. LeGrand, Sutcliff & Gell, Ltd. The Brewery has been demolished and the site—adjacent to the 'Cross Guns,' High Street, King's Heath—built over. Partial record with classification of beds by W. J. Harrison, *Geol. Mag.*, 1886, pp. 454-455 : also *Rep. Brit. Assoc.*, 1887, p. 364 ; *Midland Naturalist*, 1885, pp. 261, 352. Surface-level.—491 ft. above O.D.

		Thickness Ft.	Depth Ft.
Post-Glacial Sands	Old well	32	32
	Red sand	4	36
Boulder Clay	Red marl and pebbles ...	8	44
	Rough ballast	12	56
Keuper Marl	Red marl	158	214
	Red marl and gypsum ...	131	345
	Marl, shale and gypsum ...	309	654
	Marl and shale	3½	657½
? Lower Keuper Sandstone	Red stone and shale ...	9½	667
	[Bore continued to		1,106½]

[In the table referred to on p. 99 the beds from 603 to 928 ft. are regarded as Lower Keuper Sandstone, and those below them as Bunter Pebble Beds or Upper Mottled Sandstone].

Harrison remarks (*Geol. Mag.*, 1886, p. 455) :—"It is possible that the 'red stone and shale'—a hard sandy marl—which forms the bottom bed now reached, marks the incoming of the Lower Keuper Sandstone."

Messrs. LeGrand, Sutcliff & Gell, Ltd., have supplied the following particulars :—

Diameter of borehole.—4 in. Depth.—1,106 ft. 6 in.

Water-level.—184 ft. ex surface.

The only section they have is " Marl and sandstone "—the latter no doubt the Lower Keuper Sandstone.

8.—*Corporation Baths, Moseley Road* (62)

Described by Dr. C. A. Matley, *Quart. Journ. Geol. Soc.*, vol. lxviii, 1912, pp. 275-276.

	Thickness Ft.	Depth Ft.
Dug well :—		
Some drift and red marl	174	174
Borehole (diameter.— 15-in. to 481½ ft.; 11-in. to 550 ft.; 10-in. to 570 ft. Subsequently bored to 727 ft.) :—		
Red marl	92	266
Red marl with gypsum	34	300
Red and grey marls ...	178	478
Grey marlstone ...	6	484
Fine red sandstone ...	12	496
Red and grey marls ...	16	512
Red sandy marls ...	2	514
Grey sandstone ...	17	531
Soft red plastic marl	26	557
Red sandstone... ...	19	576
Soft plastic marl ...	8	584
Pale-red sandstone ...	14	598
Marl	3	601
Pale-red sandstone ...	10	611
Grey sandstone ...	12	623
Red marl	47	670
Red sandstone ...	10	680
Red marl	6	686
Red sandstone ...	1	687
Loose red sandstone ...	40	727

[Dr. Matley's classification : Drift and Keuper Marl in well ; Keuper Marl to 478 ft. ; Lower Keuper Sandstone to 687 ft. ; ? Upper Mottled Sandstone to base. In the table referred to on p. 99 the base of the Marl is taken at 484 ft., and all lower strata as Lower Keuper Sandstone].

Water-level.—Boring at 570 ft. deep, 54 ft. ex surface, and subsequently 102 ft. ex surface. Supply.—At 727 ft. about 8,000 gallons per hour.

9.—*Birmingham Battery and Metal Co., Ltd., Selly Oak* (74)

Made and particulars communicated by Messrs. C. Isler & Co., Ltd., Completed 1913.

	Thickness Ft.	Depth Ft.
Soft sand	26	26
Running sand and pebbles	10	36
Sand-rock (tapped first 'spring' at 64 ft. : level then 28 ft. ex surface)	28	64
Conglomerate	10	74
Red marl	3	77
Sand-rock	9	86
Conglomerate	4	90
Soft sand-rock (tapped second 'spring' at 98 ft. : water-level fell to 68 ft. ex surface)	10	100
Sand-rock	43	143
Sandy marl	5	148
Sandy rock (bore-hole discharged air and water-level rose to 43 ft. ex surface) ...	10	158
Sand-rock	22	180
Red marl	4	184
Sand-rock (water-level gradually rose from 43 ft. to 35 ft. ex surface)	19	203
Sand-rock	47	250

Lined with 40 ft. of 18-in. tubes, top 9 in. ex surface. Water-level.—Standing, 12ft. ex surface ; pumping, 21 ft. Supply.—36,000 gallons per hour.

Possibly in Drift, in basal Lower Keuper Sandstone, and in Upper Mottled Sandstone. According to the table referred to on p. 99 the drift amounts to 32 ft., and the remainder of the bore is in Upper Mottled Sandstone and Pebble Beds.

The Austin Motor Company, Ltd., Longbridge Works.—The greater part of these Works is on the Bunter Pebble Beds ; but a fault runs under a portion of the Works east of the Rednal Road, letting down Lower Keuper Sandstone against the Pebble Beds.

The firm informs me that it " . . . takes its water supplies from the Birmingham Corporation Waterworks and from the River Rea, which flows through its land. There is no well or borehole on the property."

Ley Hill, Northfield.—¼ mile S.E. of Ley Hill. A windpump here raises water from a well about 15ft. deep in the Trappoid Breccia, which is clearly exposed in a lane-cutting near by. The well was sunk about 1905 by Mr. Chaddam of Church Lane, Northfield. G. Kunzle, who purchased the Ley Hill property from the late C. H. Palethorpe, informs me that the ram on the estate has not been used since about 1905.

' Scotland,' Northfield.—There is a windpump here ; but it has not been possible to obtain any particulars of the rocks penetrated by the well or borehole. The house is on Enville Beds below the Trappoid Breccia.

The Manor House, Northfield.[1]—The windpump here raises water, for garden purposes only, from a well (in the Lower Keuper Sandstone) 30 ft. deep, 4 ft. 6 in. in diameter (inside a brick lining), in which water stands (16th Aug., 1923) at 8 ft. ex surface. The well was dug in 1895 by estate labour.

Bromsgrove.—Maps : 182, 183 ; 54 N.W. ; 15 S.E., 16 S.W., 22 N.E., 23 N.W.

Bromsgrove Urban District is on the Lower Keuper Sandstone.

The District is supplied with excellent water mainly by gravitation from the reservoir of the East Worcestershire W. Co. at Burcot (in North Bromsgrove U.D.), but in part by private house-wells, the water in which is good as regards content of solids, although liable to local pollution. The Company's water is laid on to the houses and there are no standposts.

The Bromsgrove Brewery Co., Worcester Street, obtain part of their supply from a well, the rest from the Company.

There are no good springs in the District ; but the Keuper Sandstone and subjacent Bunter Beds are full of water.

Droitwich.—Maps : 182 ; 54 N.W., S.W. ; 22 S.W., 29 N.W.

Droitwich lies on the Keuper Marl, locally covered by sand and gravel. The River Salwarpe, flowing through the northern portion of the town, has excavated a valley in the Marl and margined itself there with peaty alluvium, sand and gravel.

In times past the town was dependent on surface wells only. Then in 1876 Waterworks were opened at Tagwell, about a mile south by east of Salters' Hall in Droitwich. They consisted of three wells—about 50 ft. deep, connected by headings—in the Keuper Marl, with a Pumping Station and reservoir near Yewtreehill Farm. The water, the late H. Hulse, Borough Engineer and Surveyor, informed me, was and is bright, hard and somewhat saline ; but the wells and Pumping Station have not been used since about 1895. The East Worcestershire W. Co. now supply Droitwich, delivering water in bulk, which is stored in the old reservoir. In 1922 the average daily consumption was 113,000 gallons. The water is laid on to the majority of the 885 houses in the town.

[1] Particulars communicated by Mrs. E. M. Cadbury.

Droitwich is, of course, famous for the brine derived from the Keuper Marl, which has yielded salt there from time immemorial. The settlement was the Salinae (salt city) of the Romans, and the Wych (salt spring) or Droitwich (legal salt right) of the Saxons. For long the right to get and sell salt was a government monopoly ; this was successfully challenged about 1670–90 by one Staynor, but the legal costs so impoverished him that the Parish Council allowed him 17/- per week for the good he had done the town and trade. In recent years the Salt Union Ltd. acquired the Salt Works in Droitwich, but demolished and cleared them all away in pursuance of their policy of concentrating the local industry at Stoke Works. The last of the Works was dismantled and removed in 1923, so that no brine is now being pumped for salt-making, the only pit and pumps in use being one on Tower Hill from which brine is pumped for the Baths.

With the East Worcestershire W. Co.'s water available, the necessity of seeking domestic supplies in the Keuper Marl beneath the town has vanished. It may be remarked, however, that with the virtual cessation of pumping, the rest-level of the brine has locally risen and overflowed at the surface, passing into the surface-water drainage—to the detriment of the Sewage Farm, and of any wrought-iron piping which the brine may encounter. Wrought-iron, which becomes softened till it can be cut with a knife, marble and cement are all attacked by brine in varying degrees, while cast-iron, like the elm-wood pipes employed in early days, is not thus corroded.

Much information about the occurrence of salt and brine at Droitwich has already been collected and summarized by Dr. R. L. Sherlock.[1] Some new details and other additional matter are given below.

As a result of continuous pumping, solution-channels are developed underground in the bed of rock-salt from which the brine is derived, and sooner or later these reveal their presence by subsidence at the surface. In his way it has been found that the main brine-channel begins beneath Oakley Farm (1½ miles southward of Salters' Hall), runs between Yewtreehill Farm and the Pumping Station, and then takes the following course : north-east, passing immediately E. of St. Peter's Vicarage ; northward ; westward under the Park ; northward below the house called ' Wychbury ' ; under High Street in Droitwich, Dodderhill church and vicarage, Westwood House, Rashwood House, south of Robin Hood Inn, Wychbold Hall, Wychbold School, and so on to Stoke Prior. S. H. Loynes of Kidderminster, who is well versed in matters appertaining to the Droitwich salt industry, tells me that the brine stream flows during pumping from Droitwich to Stoke Prior—a direction contrary to local belief, but one which is confirmed by the great strength of brine at Stoke Prior, as revealed by analysis.

The subsidence is well illustrated at Wychbury House, which is inclined bodily at a very astonishing angle ; at an old chemist's shop, now untenantable,[2] facing the Hanbury Road ; and in the flow of water, along the now concave High Street, in a direction exactly opposite to what it was in 1863.

Droitwich Borings

S. H. Loynes has communicated the following particulars of sinkings put down by his firm :

No. 1—*At Marlborough, The Vines.*—Site : about midway between Nos. 7 and 8 of Mr. Calder's map.[3] A new shaft and borehole, begun Nov. 11th, 1889, replaced an older well with boreholes on the same property.

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[1] Sherlock, R. L., Special Reports on the Mineral Resources of Great Britain (*Mem. Geol. Surv.*), vol. xviii—Rock-salt and Brine, 1921, pp. 88–94.

[2] Recently demolished and a garage erected on the site (L.R., 1929).

[3] Reproduced in Sherlock, *op. cit.*, p. 90.

[Surface-level.—About 95.6 ft. above O.D.]

	Thickness Ft.	Depth Ft.
Well	—	28½
Boring (inside tubes, 5 in. diameter) :—		
Remmel, etc. ...	6	34½
Red marl	20	54½
Sandstone, soft, white	5	59½
Marl, red and yellow...	12	71½
Gravel sand and freshwater	4½	76
Marl and gypsum ...	4	80
Hard rock marl ...	1	81
Marl and gypsum ...	62	143
Very hard rock marl	10	153
Soft measure or drop	1½	154½
Rock salt	14	168½
Soft measure or drop	1	169½
Floor at bottom, very hard		

[All in Keuper Marl]. Lined with tubes from surface to 134 ft. depth.

According to Mr. Loynes the ' freshwater ' at 76 ft. depth was very likely ' bastard brine,' i.e. of 28° to 29° strength, while a limited supply of useful brine was got at 60 ft. depth, " but as the brine generally occurs in Droitwich at about 160 to 170 ft., we made sure of getting a better supply by going deeper, but below it was absolutely dry ground all the way."

No. 2.—*At Griffin's, The Vines.* [Site : just south of the railway, in line with footpath leading south from St. Augustine's Church, and between the cottage and the railway].

Well and borehole totalled 180 ft. in depth, but the well-casing " was not sufficiently good to keep out the fresh water which occurred down to about 60 ft., so that this well proved to be useless." Both are still there, only covered over.

No. 3.—*At Wrentham.* [At No. 1 on Mr. Calder's map, and about 96 ft. above O.D.]

A borehole here yielded brine, but not so good as that in The Vines. Works were erected, however, and the first brine evaporated 15th May, 1890.

No. 4.—*At Tower Hill* [No. 20 on Mr. Calder's map]. Made, and particulars communicated by Messrs. C. Isler and Co., Ltd.

[Surface-level.—About ? 105 ft. above O.D.]

		Thickness Ft.	Depth Ft.
Shaft : (principally red marl)		90	90
Borehole (diameter, 4 in.) :—			
[Keuper Marl]	Red marl	100	190
	Red marl and gypsum	12	202
	Red marl	19	221

Water-level in dug well : 80 ft. ex surface
,, ,, bore tube : 18 ft. ex ,, [1]
Brine tapped at about 198 ft. ex surface.
Supply at 202 ft., tested with pulsometer, 3,000 gallons per hour.

Two unsuccessful borings for brine have been made in the orchard at Tagwell : one in the north-west corner, 300 ft. deep, the other in the extreme south, 500 ft.

Droitwich Brine Baths

The therapeutic properties of the brine were discovered by accident in 1832, during an epidemic of cholera. A patient, it is said, had been ordered a hot bath, but as no hot fresh water was available he was put in a bath of hot brine from a neighbouring salt-works. So speedy was the patient's recovery, that a similar cure was prescribed for all the cholera patients and the death rate went down to an astonishing degree. Further research proved the

[1] Now 20 ft. ex surface (J. H. Hollyer, Manager, Corbett Estate Office, *in litt.*, 11th July, 1923).

efficacy of hot brine treatment in cases of rheumatism, sciatica, gout and allied complaints. From Dr. W. Mackower's estimate [1] the amount of radium present may be deduced to be 1 part (by weight) in 4 million parts of brine—roughly one-seventh of the amount in the strongly radio-active King's Well at Bath.

In 1836 the first Public Baths were opened and so much attention did they attract, that in 1855 Mr. Gabb, an enterprising resident who did much to improve matters single-handed, was able to provide additional Baths. In 1870 the late Dr. Bainbridge took over the Baths, and with the assistance of a Mr. Rock, improved and added to what Mr. Gabb had already done at the Royal Baths.

These Royal Baths, and the neighbouring old Royal Hotel (since pulled down), passed into the hands of the late John Corbett, who built near the Baths a new Royal Hotel, and in 1887 erected the St. Andrew's Baths. He also converted St. Andrew's House into the Raven Hotel and built the Worcestershire Brine Baths Hotel.

Dudley.—Maps : 167, 168 ; 62 S.W. ; 1 S.E., 4 N.E.

The Borough of Dudley is on Coal Measures, except for small upfolds of Silurian and Downtonian rocks (1) around The Castle, near Dudley Station, (2) at Saltwells, near Netherton, and for the area of basalt at Kates Hill, the north-western extremity of the Rowley Hills mass. The igneous rock is of later date than the Coal Measures with which it is associated, while the Silurian and Downtonian rocks formed an irregular floor on which the Coal Measures were laid down.[2]

The Coal Measures, although locally waterlogged for reasons given on an earlier page (p. 21), are not a very useful source of potable water : the history of the water-supply of the Borough shows this. The best water—but it is in very limited quantity—is that encountered in the decomposed portions of the igneous rock and in the many fissures with which it is riven.

Until about 1791 the inhabitants were dependent entirely on private wells from 15 to 180 ft. deep (about half of which were fitted with pumps), rain-water cisterns (usually below ground and fitted with pumps), ponds, and a few public wells. In that year The Town Act (31 Geo. III, c. 79, s. 25) gave power to obtain and convey water to the town. Works were constructed under the authority of that Act, but were found to be insufficient and were later abandoned. About 1827 William Richardson was instructed to ascertain whether the town could be supplied under the old Act and also the condition of the abandoned waterworks. He found that the springs had become so lost and diverted as to be of no value whatever. The matter remained dormant, each inhabitant fending for himself, until 1834 when the Dudley Waterworks Company was formed and an Act (4 William 4 cap. 13) obtained for supplying the Borough of Dudley and the neighbourhood thereof ; Richardson was appointed engineer. The works then constructed were :—a reservoir, to which water was pumped from surface springs ; Parkes Hall Pumping Station (where there was a shaft 90 ft. deep with headings) and Hurst Hill Pumping Station (well) ; pipes were laid in Dudley, Sedgeley and Bilston. The Company were faced with many difficulties : the hilly nature of the district made the system of mains intricate ; the supply of surface-water fell off, and much water was lost by mining operations. Such steps as could be taken to provide water were taken. Some seven public wells were repaired and fitted with pumps. It is said that there was always ample water in the ' green rock ' (basalt) and some of the wells were in that rock. But in 1852 William Lee reported that these wells were now covered up ; the railway

[1] Quoted in Sherlock, *op. cit.*, p. 12.

[2] For an account of the rocks around Dudley, see ' Geology of the Southern Part of the S. Staffs. Coalfield ' (*Mem. Geol. Surv.*), 1927 ; their outcrops at the surface are shown on Plate II of that work.

tunnel having drawn off the great bulk of the water.[1] Six of the seven wells tapped springs at about 30 ft. down, being surface supply and very uncertain in summer ; while the seventh ' well ' was a cistern, fitted with a pump which was fed with water from the roof of the parish church.

Until 1862, then, great difficulty was experienced in obtaining supplies, and the poorer people in particular suffered great privation. In May of that year the South Staffordshire Waterworks Company took over the Dudley water supply, under the Act of 1853 ; but Fred J. Dixon (Engineer-in-Chief of the Company) informs me that the only part of the works taken over which is still in use (after reconstruction) is the Shavers End Reservoir—near Dudley, but in Staffordshire. The Company's water is now laid on to some 10,718 out of 10,761 houses in the Borough and to a few standposts : the more or less scattered cottages in various parts of the Borough not so served, F. Atkinson (the Chief Sanitary Inspector) tells me, are dependent on wells and springs of small volume. Messrs. Julia Hanson and Sons, Ltd., Brewery, Town Street, had at one time a well about 90 ft. deep that went into some old workings ; but Mr. Hanson informs me that the water was used only for washing and cooking purposes and that the well is now filled in, its use being expensive and unsatisfactory. Messrs. Thomas Plant and Co. had a borehole at their Steam Brewery, Netherton, but the Manager tells me it proved an absolute failure.

Saltwells Spa

This " Spa " (called " Cadley Spa " in a directory of 1836) is situated some two miles south of Dudley. It consists of a well (fitted with a hand-pump) in Kingswinford parish, and baths (three ordinary plunge-baths each in a separate room with facilities for heating the waters) close by, but in the borough of Dudley. In the past the " Spa " has been known as " Lady Ward's Saline Spa," and " Lady's Well," because it was just outside ground called " My Lady's Coppice " that was enclosed by Lady Ward. It belongs to the Earl of Dudley ; but is now leased to Messrs. Thomas Plant and Co., of the Steam Brewery, Netherton, and was renovated in 1922.

The well is about 36 ft. deep, and 7 ft. 6 in. in diameter. It passes through the Temeside Shales and into the Downton Castle Sandstone of the Downtonian group of the Lower Old Red Sandstone. These Downtonian beds underlie immediately the Coal Measures of this part of the South Staffordshire Coalfield, and are the source of the saline waters—although nothing like the strength of the Saltwells waters—encountered in many of the pits.

At Saltwells these saliferous Downtonian beds emerge—along with Silurian strata (Upper Ludlow)—on the line of the Netherton anticline from amid Coal Measures in which the Thick Coal was once worked within a very short distance of the springs. The identification of the beds from which the salt waters at Saltwells come as Downtonian was due to Mr. W. Wickham King and Mr. W. J. Lewis in 1912.[2]

The salinity of the waters and their beneficial effects have been known from what may be described as " time immemorial." Dr. Robert Plot, in his " Natural History of Staffordshire," published in 1636, refers to them as " weak brine," from which he says Lord Ward attempted to obtain salt, but desisted because the strength was insufficient to make the industry a success.

In 1809, W. Weldon [3] examined the source of the waters (Analyses 669, 670 below).

" The saline spring flows into a well, near a ridge of high land, on the sides of which, at some short distance, coals and ironstone are seen cropping out. The well is about 36 ft. in depth, and 7½ ft. in diameter. The sides have lately been fenced, to keep out foreign water, which was supposed to run into it, with a dam of bricks set in clay, and lined with elm boards.

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[1] Report to the General Board of Health on a Preliminary Inquiry into the . . . supply of water . . . of Dudley, 1852.

[2] *Geol. Mag.*, 1912, p. 437. See also ' The Southern Part of the South Staffordshire Coalfield ' (*Mem. Geol. Surv.*), 1927, pp. 9–23.

[3] *Journ. Nat. Phil., Chem. and Arts*, vol. xxii, 1809, pp. 266–279.

" The bottom is a ferruginous sandstone, through which is perforated a hole, whence the water issues and rises to within about four feet of the surface.

" The sides of the well near the top are covered with a yellowish ochrey substance. When the water is fresh taken up, it is perfectly transparent and colourless. . . . After a time the water becomes rather turbid, and at length a pale ochreous precipitate falls down leaving the supernatant water transparent.

" In large quantity the water smells of sulphuretted hydrogen, but if half a pint or less be examined apart the odour is hardly perceptible.

" When the temperature of the atmosphere indicated 40° of Fahrenheit, some water just taken from the well raised the thermometer to 47½°. At another time when the temperature of the surrounding air was 75°, water taken from near the surface of the well lowered the thermometer to 56°, and a portion taken from the bottom to 52°.

" The taste of the water very much resembles the taste of sea water. The specific gravity of the water is found to differ at different depths from the surface. It differs also very considerably at different times. . . ."

The dam made to exclude the surface water was at first constructed of bricks set in common lime mortar, then in a grey lime (" which the neighbourhood affords ") ; but in both cases the salt water destroyed its cementing power. Afterwards the bricks were set in a strong clay, free, or nearly free, from lime and this proved effective.

Weldon then details how he examined the water.

Dr. C. Hastings, in his " Illustrations of the Natural History of Worcestershire " (1834, pp. 118–119) says that the spring yielded about eight gallons per day and that the water had strong purgative qualities.

Dr. A. B. Granville's impressions of the Spa were not very flattering[1] :—

" It is but a poor concern at present. The well from which the mineral water is pumped by an ordinary pump is covered over ; and a small building has just been erected, like a cottage, by the side of it, with two indifferent looking bath rooms. The supply of water is not plentiful, being about 20 hogsheads in a day only.

" The water is clear, its taste is strongly salt, with a degree of bitterness so marked, though not unpleasant, that it will linger a long time on the palate. Its temperature, I ascertained to be 50° of Fahrenheit. Mr. Cooper, the London chemist, has found by an accurate analysis, which is printed and circulated at the Spa, 80 grains, and a little more than half a grain besides of saline ingredients, in the dry state—that is, without any water of crystallisation. In a wine-pint of the mineral water, nearly 50 grains of that quantity are of common salt, 19 are muriate of lime, and seven and a half muriate of magnesia. There is both a muriate and a carbonate of iron, making altogether a grain and a fraction ; but neither iodine nor bromine has been found in the water."

Thomas Baker, in " Baker's Practical Survey of the Geology, Mineralogy and Historical Events of the District of Dudley "[2] states that his knowledge of the Saltwells went back about 70 years. He recollected the well neglected, nearly grown over with shrubs, and the surface water running in and mixing with the salt water. " The water was taken out with cups or other vessels as it was wanted. There was no bath or any such thing." He then recounts the sinking of the well described by Weldon, the steps taken to keep out surface water, the erection of a baths, and the demolition and rebuilding of the inn.

In 1907 a well-illustrated account of Saltwells appeared in Blocksidge's " Dudley Almanack," with a new analysis (No. 671 below) which shows 45.98 grains of sodium chloride per gallon more than in the Tenbury water.

A gentleman who is now [1922] nearly 90 years of age recollects that when a boy the springs were constantly used, and that people visited them, and used them much as they do the Droitwich Brine Baths at the present day.[3]

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[1] Spas of England—Midland Spas, 1841, pp. 144, 145.
[2] 1848, p. 67.
[3] L. Richardson, *Trans. Worcs. Nat. Club*, vol. vii, pt. 5 for 1922 (1923), pp. 387–391.

Evesham.—Maps : 200 ; 44, 54 S.W. ; 42 S.E., 49 N.E.

Evesham town is situate on a promontory on the right bank of the Stratford Avon and its suburb Bengeworth on the left bank. It is on the Lower Lias, with a river-terrace of gravel on the high ground, and another, at a lower level, bordering the river and mostly overspread by Alluvium. Locally, Lias occurs at the surface without a covering of gravel.

The town was originally dependent on shallow wells and river water. One well, sunk in 1832 in the Lower Lias clay in Bengeworth, tapped a " copious saline spring " which, when analysed by a Mr. Hodgson of Apothecaries' Hall in 1834, was found to contain, in one imperial pint, carbonate of lime, 3 grs. ; sulphate of soda, 14.6 grs. ; and chloride of sodium, 45 grs.[1] and was compared to the water of the Cheltenham Saline Spring.

The shallow wells becoming badly polluted, a new source of supply had to be discovered. Springs, issuing from the Inferior Oolite and Cotteswold Sands on Upper Lias clay, were found on the escarpment of the Cotteswold Hills in Broadway parish, and Waterworks were formally opened on January 1st, 1884 and added to in 1904. The water is now laid on to the houses in the town and few wells are in use.

Borough of Evesham Waterworks

Supply Evesham Borough, and furnish water in bulk to the Evesham R.D.C. for part of Norton and Lenchwick parish. The Corporation is bound to supply 2,000 gallons per day, free of charge, to Childswickham, Glos., through which parish the main passes.

Source of supply—Springs at Middle Hill, Broadway. There has been a decrease in volume since the drought of 1921. Works—Three service reservoirs close to the Evesham-Broadway road in Childswickham parish holding respectively 130,000, 475,000, and 2,000,000 gallons. No filtration. Quantity of water supplied—The daily average is 400,000 gallons. Quality—Composition of the water has shown little variation during the past thirty years and is of excellent quality. Analyses, Nos. 219–226.

Battlewell

This ' well ' is now simply a field-pond situate at the head of a valley running down to the River Avon. It is reached through the iron gate on the west side of the Alcester Road, just within the borough boundary and before the turning to Pershore and Worcester. The ' well ' will be observed in the second field to the north-west with low retaining walls on two sides. It is fed with water draining out of ' Northern Drift ' (gravel) resting on Lower Lias clay. A marked channel running from the pond down the valley seems to indicate occasional overflow, though there was none on Sept. 8th, 1924. It was by this ' well ' that Simon de Montfort was slain at the Battle of Evesham in 1265.[2]

' Eye Well ' [3]

On the right hand side of the path leading across the meadow from the railway (at the end of Blayney's Lane) to Offenham ferry is a spring issuing from the base of a marked river-terrace of sand and gravel which rests on Lower Lias clay. The water runs out of an agricultural pipe into a little ' dip,' and, Arthur W. Ward informs me, is said to be " good for the eyes."

Kidderminster.—Maps : 182 ; 54 N.W., 55 N.E. ; 8 S.W., S.E., 14 N.W., N.E.

Roughly speaking, the western two-thirds of the Borough is on the Pebble Beds or Middle Bunter ; the remainder on the Upper Mottled Sandstone. The Pebble Beds have a prevalent south-easterly dip ; the Upper Mottled

[1] That is respectively 34, 167, and 514 (total 715) parts per 100,000.

[2] George May, " The History of Evesham," 1834, pp. 14, 15.

[3] For further reference to this well and its miraculous curative powers see [Sir] C. W. Oman, *Trans. Bristol and Glos. Arch. Soc.*, vol. xxxii, pt. i for 1909, p. 791 (footnote) ; Rishanger's " Chronica," *Camden Soc.* ; W. H. Blaauw, ' The Barons' War (1st ed., 1844 ; 2nd ed., 1871), p. 277 ; E. A. B. Barnard, ' Guide to Evesham,' 4th ed., p. 45 ; and the same author in ' Evesham & Four Shires Notes & Queries,' vol. ii, 1911, p. 152. Evesham.

Sandstone is thus brought on and forms the high ground in the neighbourhood of St. George's Church. An important fault, however, runs from near the Railway Station, south-westwards between the Sewage Works and Aggborough Farm, through Oldington Wood and beyond, and north-north-eastwards to Podmore Pool and beyond. By this fault the Upper Mottled Sandstone to the east has been let down and brought into juxtaposition with the lower beds of the same subdivision in the neighbourhood of St. George's Church and with the Pebble Beds from near Aggborough Farm south-westwards. The River Stour has reduced the area of Upper Mottled Sandstone to the west of the fault and has excavated a valley in the Pebble Beds in which lies the industrial part of Kidderminster.

The Pebble Beds and subjacent Lower Mottled Sandstone are so full of water (J. T. Cowderoy, the Sanitary Inspector, informs me) that on a Sunday, when the various Carpet and Spinning Works are not pumping from their wells or boreholes, many of the wells overflow (see also pp. 26, 112, 113).

The water-supply of Kidderminster was very badly spoken of in the Sixth Report (1874) of the Rivers Pollution Commission (p. 361) :—" Kidderminster, . . . a borough of 19,463 inhabitants [in 1911, 27,544] is supplied with water for domestic purposes from shallow private wells and . . . from a neighbouring polluted river. . . . The supply is filthy and altogether inadequate for the requirements of the population. The town stands on New Red Sandstone, which supplies the deep wells of the manufactories with potable water of excellent quality, as is seen from the analytical results yielded by our sample from the deep well in Messrs. Brenton [Brinton] & Lewis's mill [now Brinton's, Ltd.] furnishing 100,000 gallons per day [Analysis No. 629]. One of the two shallow wells, which were pointed out to us as yielding water of average quality, was situated in Mr. Alderman Tovey's courtyard, it was only 5 ft. deep and contained a liquid [Analysis No. 630] which was very similar in composition to that which we have obtained in our laboratory, by allowing London sewage to soak slowly through 5 ft. of gravel . . . The other well . . . contained water which analysis [No. 631] shows to have had a like origin, but the animal matters had been somewhat more oxidized than those in the water of Alderman Tovey's well, consequently the present pollution was less, whilst the previous contamination was greater. We do not remember to have visited a town of this size in which the water supply has been so completely neglected. The splendid water in the New Red Sandstone immediately beneath the town ought to render easy to the inhabitants of Kidderminster a remedy for this state of things."

This state of things has been remedied : town water of excellent quality is now laid on to every property.

Kidderminster Waterworks

(Kidderminster Borough Council)

Supply Kidderminster and parts of the parishes of Hartlebury (Droitwich R.D.), Kidderminster Foreign, and Wolverley (Kidderminster R.D.).

Sources of Supply—Wells in Pebble Beds and ? Lower Mottled Sandstone.

Well	No. 1	No. 2	No. 3	No. 4
Surface level (ft. O.D.) ...	About 168		Abt. 98	98
Depth of shaft (ft.)	113	—	Abt. 30	50
,, ,, borehole (ft.) ...	480	626	300	308
Diam. of shaft (ft.)	8	4½	10	10
,, of borehole (in.) ...	12	12 to 500 ft. ; then 6	9 and 6	12
Depth to water-level from surface (ft.)	70	70	1½ to 2	1½ to 2
Yield (galls. per hr.)	13,200		—	72,000

The maximum yield per 24 hrs. of Nos. 1, 2 and 3 wells together is 916,800 gallons ; that of No. 4 is 1½ million gallons when the rest-level falls to 45 ft. below the engine-room floor. When pumping is not in progress No. 4 overflows into the River Stour ; it showed no diminution in 1921.

Wells No. 1 and No. 2 (30 ft. apart and connected by a heading about 100 ft. below the surface) are at the Upper Pumping Station, situated near the Stourport Road one mile south of the town ; No. 3 is at the Sewage Works, and No. 4 at Green Street Pumping Station. Nos. 1, 2 and 3 now serve as a stand-by, and are only used when repairs have to be executed at the Green Street Station. No. 3 was originally made to supply water for the condensers of the former Sewage Pumping Engines, and was brought into use to supplement Nos. 1 and 2 about the year 1881. No. 4 was sunk in 1899. In No. 1 Well water is said to enter mostly at 450 ft. down. The bottom 460 ft. of No. 2 are silted up.

Works.—No filtration. Service reservoir—Sutton Park Road : capacity, 1,971,000 gallons : bottom 271.5 ft. above O.D. ; overflow, 286.5 ft. above O.D. (i.e. depth, 15 ft.). The highest parts within the area of distribution are—Bewdley Hill, 265 ft. ; Green Hill, 231 ft. ; and Hill Grove, 244 ft. The present reservoir was opened September 26th, 1886 ; the former reservoir by the Upper Pumping Station, constructed in 1873, is now used as a swimming bath.

Quantity of water supplied.—The daily average is from 1,125,000 to 1,250,000 gallons. Supply is constant. Quality—See Analysis No. 338.

I am indebted to Bernard J. Green, Waterworks Engineer, for much of the information given concerning the Waterworks.

Lea Bank Spring, Bewdley Hill.—A small spring running to waste issues here from near the base of the Pebble Beds, and is chalybeate, as may be observed from its rust-coloured deposit. The fountain was erected by Walter Hemming in the sixties of the past century.

Kidderminster Borings

1.—*'Black Well,' Kidderminster Brewery Co., Blackwell Street*
(Successors to Messrs. Bucknall & Co.)

Boring made and particulars communicated by Messrs. C. Isler & Co., Ltd

		Thickness Ft.	Depth Ft.
[Pebble Beds]	Dug well [Black Well] :—		
	[? Sandstone]	36	36
	Boring (diameter, 6 in.) :—		
	Sandstone	6	42
	Red marl	5	47
	Red sandstone	36	83
	Sandstone	62	145
	Red marl and sandstone	27	172
	Red marl and sandstone	15	187
	Sandstone	93	280

Water-level.—29 ft. below the surface.

John J. Jones, Kidderminster, informs me that the Black Well was widely used as the water supply in this populous locality before the Corporation water scheme was carried out. The well is at the back of the Brewery premises, and, in their early days, Messrs. Bucknall & Co. were content to obtain their water from this well ; but about 1870 made the above-described bore and obtained an abundant supply.

2.—*Boring in Mill Street*

Probably at Messrs. Humphries, now Carpet Trades Ltd.
Boring completed 31st January, 1875.

		Thickness Ft.	In.	Depth Ft.	In.
	Shaft (diameter, 11 ft.) :—				
	1. Soil	6	0	6	0
Alluvium.	2. Pure clay	1	0	7	0
River Gravel.	3. Gravel	9	0	16	0
	4. Red sandstone	8	0	24	0
	Boring (diameter, 6 in.) :—				
	5. Red sandstone	7	0	31	0
	6. Red sandstone with pebbles	16	2	47	2
	7. Red sandstone with fewer pebbles	4	6	51	8
	8. Red sandstone with still fewer pebbles and softer ...	6	0	57	8
	9. Red sandstone	32	6	90	2
	10. Red marl		6	90	8
	11. Red sandstone	4	10	95	6
	12. Red sandstone, gritty, not hard	9	0	104	6
	13. Red sandstone, very hard	23	2	127	8
	14. Red sandstone, very hard with quartz pebbles, (locally called " cat-brain")	5	9	133	5
	15. Red sandstone, soft ...		9	134	2
	16. Red sandstone, very hard	16	10	151	0
	17. Red sandstone, softer rock	7	8	158	8
Pebble Beds	18. Red sandstone, hard ...	4	3	162	11
	19. Red sandstone, not so hard, with open cleft or fault, and much sand washed up	7	9	170	8
	20. Red sandstone, hard, with pebbles	4	7	175	3
	Fault	1	5	176	8
	21. Red sandstone, hard ...	3	6	180	2
	22. Marl		6	180	8
	23. Red sandstone	8	5	189	1
	24. Marl	1	0	190	1
	25. Red sandstone, very hard	3	0	193	1
	Fault or open cleft		4	193	5
	26. Red sandstone	2	7	196	0
	27. Marl		6	196	6
	28. Red sandstone, very hard	4	3	200	9
	29. Red sandstone, very hard, with quartz pebbles ...	4	0	204	9
	30. Alternating with a few inches of hard rock and marl	6	4	211	1
Lower Mottled Sandstone	31. Very soft [sandstone ?] from which spring volumes of water	13	8	224	9

3.—*Messrs. J. P. Harvey & Co., Ltd., Mill Street*

S. H. Loynes tells me :—" My firm [Messrs. J. P. Harvey & Co., Ltd.] have a well at our Mill in Mill Street for the purpose of getting clean water for washing our wheats. There seems to be a most abundant supply, and some years ago, so much so, that there used to be a spring bubbling over the top, but since various other wells have been sunk, it has lowered the rest-level, so that overflow does not take place. Water in Mill Street occurs, I believe, in gravels [Pebble Beds] about 30 to 40 ft. from the surface. I believe I am correct in saying that our own bore was carried down about 60 ft. before we got an ample supply."

4.—*Great Western Railway*

Made and particulars communicated by Messrs. C. Isler & Co., Ltd.

		Thickness Ft.	Depth Ft.
	Peat	5	5
	Sand and pebbles	12	17
[Drift]	Loamy sand	63	80
[Pebble Beds]	Sandstone	232	312
	Marl	9	321
[Lower Mottled Sandstone]	Sandstone	69	390
	Sandstone and pebbles	111	501

Lined with 80 ft. of 11½-in. tubes, top 1 ft. below surface.
Supply.—14,262 gallons per hour.

5.—*Pike Mills, Green Street*

(Messrs. T. & A. Naylor)

Completed May 1920, and particulars communicated by Messrs. C. Isler & Co., Ltd.

	Thickness Ft.	Depth Ft.		Thickness Ft.	Depth Ft.
Made ground... ...	4½	4½	Red marl and layers of sandstone ...	8	126
Red clay	3	7½	Red sandstone ...	46	172
Red and yellow clay	4	11½	Red sandstone and conglomerate ...	9	181
Ballast	5	16½	Red marl	1	182
Red sandstone ...	44½	61	Red sandstone and layers of conglomerate	52	234
Red sandstone and layers of conglomerate	14	75	Coarse red sandstone and layers of conglomerate	33	267
Conglomerate ...	3	78	Conglomerate	13	280
Red sandstone ...	13	91			
Red marl	4	95			
Red sandstone ...	23	118			

[River deposits and ? Drift to 16½ ft. ; remainder, Pebble Beds]
Lined with 22 ft. 9 in. of 10 in. tubes, top 2 ft. below surface.
,, ,, 40 ft. of 8 in. tubes, ,, 1 ft. 6 in. below surface.
Supply.—6,260 gallons per hour. Water-level.—Standing, 4 ft. ex surface ; pumping, 19 ft. 6 in. ex surface.

6.—*Other Boreholes at Carpet Works and Spinning Factories*

Site and date of sinking	Depth Shaft (ft.)	Depth Bore (ft.)	Diameter Shaft (ft.)	Diameter Bore (in.)	Depth to rest-level (ft.)	Yield per day (galls.)
Chlidema Carpet Co., Ltd., Green Street. 1872.	24	250	7	6 at top, then 4	16	—[1]
Empire Carpet Co., Foley Park. 1898.[5]	28	200	2	8	30[2]	3,000–4,000
Victoria Carpet Co., Green Street. 1876[6]	25	140	12	—[3]	8[4]	16,800

[1] The pump connected with this well has a bucket 13 in. diameter, 12-in. stroke, 64 strokes per minute making 48 hours per week.
[2] A permanent lowering in rest-level of about 18 in. has been observed.
[3] Two inlets : 4 in. and 3 in.
[4] Now (1929) 10ft.; apermanent lowering in rest-level of about 3 ft. has been observed.
[5] This borehole was made by the late firm of Thomas and Wilkes, Kidderminster, for washing gravel intended for filter beds in connexion with the Birmingham Welsh Water Scheme.
[6] For this firm's new borehole, see Appendix, p. 215.

Site and date of sinking	Depth Shaft (ft.)	Depth Bore (ft.)	Diameter Shaft (ft.)	Diameter Bore (in.)	Depth to rest-level (ft.)	Yield per day (galls.)
Messrs. Woodward, Grosvenor, Ltd :—						
(a) Green Street. 1897	18	200	—	—	18	72,000
(b) Worcester Cross. 1883.[1]	30	250	9½	8	30	8,000
Messrs. Brintons, Ltd. 1866	24	200	11	6	about 11	—[2]

Lye and Wollescote.—Maps : 167 ; 62 S.W. ; 4 S.W., S.E.

Lye is on the Coal Measures (which rest on Downtonian) except for a small tract—300 yds. by 100 yds.—at The Hayes, where Downton Castle Sandstone (13 ft. 9 in. seen) and Upper Ludlow and Aymestry Limestone (65 ft. 6 in. thick) emerge at the surface on the line of the Netherton anticline.[3]

All the houses in Lye are connected with the mains of the Stourbridge and District Water Board's Waterworks. A spring called the " Spout Field Spring," situate between Cemetery and Ludgebridge Brook Roads, at one time served many houses, but they are now connected with the mains.

At Messrs. James & Philip Round's Galvanizing Works in Jackson Street, Lye, is a well and borehole of which the firm has supplied the following particulars :—

Sunk in 1912 by Benjamin Hart. Shaft :—Depth 93 ft. ; diameter 2 in. Depth from surface to rest-level of water—76 ft. Daily average quantity of water pumped—2,000 gallons. No permanent lowering in the rest-level of the water has taken place.

At Messrs. Eveson Bros. works in Providence Street, about 150 yds. N. of Lye church, a recent boring at the bottom of a well 36 ft. deep proved 240 ft. of Downtonian strata (purple and green marls with occasional sandstone bands of the same colours).[4]

Malvern Urban District.—Maps : 199 ; 43 N.E., 55 S.E. ; 39 N.E., S.E., 40 N.W., S.W., 46 N.E., 47 N.W.

The Malvern Urban District, embracing Great Malvern, Malvern Link, West Malvern, and Malvern Wells, is a country of two extremes of land-relief—the mountain-like Malvern Hills (Worcestershire Beacon, 1,395.2 ft.) in the west and vale-land in the east.

The Malvern Hills are mainly composed of Archaean rocks belonging to the Malvernian group and are red binary granites (formerly called ' syenite '), gneisses, epidiorites and schists. Younger Archaean rocks, belonging to the Uriconian and comprising rhyolites, andesites, basalts and tuffs, compose Tinker's Hill, Broad Down and Hangman's Hill alongside the Herefordshire Beacon to the east and south-east. Small tracts of Palaeozoic rocks occur (1) in the valley of the White-leaved Oak : Cambrian quartzite (Malvern Quartzite), sandstone (Hollybush Sandstone), and shales (White-leaved Oak Shales and Bronsil Shales) ; (2) east of Swinyard Hill : Silurian (May Hill Sandstone and Tarannon Shales) ; and (3) in the neighbourhood of West Malvern : higher Silurian strata.

Faults separate the Archaean from the younger rocks along both sides of the hills. By that along the east side the strata have been let down some hundreds of feet, so that between North End and Great Malvern the Lower Keuper Sandstone abuts against the Archaean ; but south of Great Malvern

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1 Sunk by Messrs. Thomas and Wilkes.

2 Present yield not known ; about the year 1868 yield was 100,000 gallons per day.

3 King, W. Wickham, and W. J. Lewis, *Geol. Mag.*, 1912, pp. 439, 440. See also ' The Geology of the Southern Part of the South Staffordshire Coalfield ' (*Mem. Geol. Surv.*), 1927, pp. 9, 17, 18, with Plate II (map).

4 Information from W. Wickham King.

the downthrow has increased, and it is the succeeding Keuper Marl that is found in juxtaposition. Even between North End and Great Malvern the thickness of Marl left by the processes of denudation rapidly increases away from the hills, until at the Gas Works, Malvern Link, a mile and three-quarters from the outcrop of the Sandstone, borings (p. 125) proved 703 feet of Marl before the Sandstone was reached.

The following wells in Keuper Marl may be mentioned here although they did not reach its base :—

	Depth in feet
Link Top	117
Police Station	123
Between Vicarage and Holy Trinity Church ...	105
Zetland Road	173

From records of the water collected high up in the catchment drains of the Waterworks, it would appear that out of some 26¾ inches of rain falling on the Malvern Hills, 22 inches is lost by evaporation and by disappearance into the numerous fissures, large and small, with which the Archaean rocks are riven. Much of what has disappeared high up, however, reappears as springs at lower levels. That which percolates through the scanty soil of the upper part of the hills or issues from the Archaean rocks is remarkably pure and its mineral contents very low (Analyses 653, 654). But where the waters issue near the junction of the Archaean rocks with the Silurian on the west or with hill and other rock débris (Malvern Drift) on the east, they are found to have taken up mineral matter from the rocks with which they have come in contact. As noticed by Edwin Lees,[1] they have become so hard in the former case that many make deposits of carbonate of lime (' petrifying springs ') ; in the latter case, they are often slightly chalybeate, sufficiently so to be highly coloured, if not otherwise appreciably altered.

Edwin Lees drew attention to the Hay Well—" a very copious spring, now enclosed " ; but remarked that throughout the range there was no very copious outburst of water—the most powerful stream, he said, was that which had its genesis in several springs (whose waters are now impounded—except for compensation water—in The Camp Reservoir) in the eastern side of the Herefordshire Beacon ; while a " loud-voiced brook " came down the Gullet Pass.[1]

Arthur Bennett of Upper Colwall, who has studied the geology of the district for many years, has favoured me with the following observations :—

" Owing to the broken nature of the Malvernian (Archaean) rocks and the relatively impermeable nature of the Silurian and Keuper rocks (west and east of the boundary faults) there is a tendency for the rain which falls upon the Hills to soak down into the rock and issue as ' fault-springs ' at the junctions of the Silurian and Keuper with the Malvernian rocks. These springs are of remarkable organic and mineral purity, but the contact of the water with the Palaeozoic and Mesozoic rocks imparts some degree of hardness.

" In the case of St. Ann's Well and of the Holy Well, which issue well above the fault-line, the water never comes in contact with any rock other than Malvernian, and, owing to the practical insolubility of the rock the water from these springs is of exceptional purity and softness.

" It is noteworthy that the fault-springs have determined the positions of the various villages which now make up Malvern. Going back, say 35 years—before the extension and amalgamation of the Malverns—all the villages, except Great Malvern, were dependent upon the water afforded by shallow wells and springs: consequently, those villages sprang up in the vicinity of those fault-springs. Such was the origin of Malvern Wells, West Malvern, Upper Colwall, and lesser places such as Little Malvern, Lower Wyche, Brand Green, etc., and it is curious to note that the principal roads run along the fault-lines from village to village, e.g., Worcester Road, West Malvern Road, and Old Road from Wyche to British Camp : there are also corresponding bridle-roads to the South Malverns.

[1] ' Pictures of Nature around the Malvern Hills,' 1856, p. 103.
[2] *Ibid.*

" I will now mention a few of the springs :—the " Eye Well," Malvern Wells ; Holy Well, Malvern Wells ; St. Ann's Well, Great Malvern ; and Walm's Well. North Malvern and West Malvern are full of shallow wells and fault-springs—formerly the only supplies.

" Following the western fault-line southwards we come to ' The Dingle,' which rises in the Archaean and lower down is supplemented by fault-springs. Then the ' Haysladd ' (west of Worcestershire Beacon), which is a fault-spring associated with a small bog containing several rare plants—*Drosera*, *Pinguicula*, etc. This spring is now one of the important supplies to the Malvern U.D.C. Waterworks. Next the Royal Well Springs (in Colwall parish, Herefordshire) at the head of Purlieu Lane—supporting Berkeley's Royal Well Mineral Water Works and the Royal Well Brewery.[1] Then the little fountain on the west side of the Wyche Cutting—a pure Archaean spring: not a fault-spring. From this well is also laid a private supply to Mr. Grundy's bake-house at the Upper Wyche Post Office. Further south is ' Willow Spring.' Then several springs near The Cross Inn, including the supplies for Ballard's private undertaking. ' Moorally ' Well is also here and issues, I think, a little above the fault-line. Note that these springs occur along the old road to the British Camp and that the up and down nature of the fault junction caused the road to be up and down and necessitated the new road, known as the ' Jubilee Drive,' engineered to an even gradient. Then we have springs at Gardener's Common and Broad Green—the latter supplying residences such as Brand Lodge and Perry Croft. Another famous spring is that of Pewtriss, Putress or Putriss—a large fault-spring, recently excavated, tanked and supplied to Schweppe's local Mineral Water Works near Colwall Station."

The Malvern Waters

1.—*Historical.*—Contributed by Mr. F. C. Morgan, Public Librarian Malvern.

The first mention in print of Malvern Waters being used for medicinal purposes is in ' A Treatise of One Hundred and Thirteen Diseases of the Eyes and Eyelids ' by Richard Banister, 1622. The next mention was in 1666, when Dr. John Beale contributed ' An Account of some Sanative Waters in Herefordshire,' to the Royal Society, recording the first actual cases of ' Cures,' but the wells are said to be in Herefordshire, which makes their identification uncertain. Legend places the ' Eye Well ' at a spot about 200 yards south of the ' Holy Well,' in Worcestershire, and possibly the second well was that known as ' Walm's Well.' This well had a great reputation in the 17th Century for curing diseases of the skin.

In 1756, Dr. John Wall, of Worcester, published the first edition of his famous ' Experiments and Observations on the Malvern Water.' Later editions of his work record many cases of supposed wonderful cures. The fourth edition contained some verses, said to date from 1590, although perhaps written by the Rev. Edmund Lea about 1612. They cannot be later than 1630, when Malvern Chase was disafforested, as deer are therein mentioned. Reference is made to the number of poor who resorted to the wells to bathe sores, etc., and to the lack of accommodation. The profits of Dr. John Wall's book, together with subscriptions, were devoted to assisting the many needy sick who came for treatment. Until early in the 19th Century baths or sheds built by these means stood near the principal springs. The buildings at ' Holy Well ' and ' St. Ann's Well ' were later altered and improved and used by water-drinkers only : that at ' Walm's Well ' entirely disappeared years ago, and the ' Chalybeate Spa ' is now in the grounds of a private residence and was sealed up for many years.

In the late 18th Century, Malvern Wells appears to have been the fashionable part of the district and several large boarding houses were built there for wealthy visitors.

Early in the 19th Century, Great Malvern began to attract visitors, and soon became more popular than Malvern Wells. Baths, Hotels, the Royal

[1] Near the derelict Spa Hall.

Library, and many private dwellings were erected, and the natural attractions of the town, and the water of ' St. Ann's Well,' the ' Chalybeate Spa,' etc., exploited to the utmost. The popularity of the ' Water Cure,' however, gradually waned, and when the hills were channelled with catch-pipes for the town supply in the middle of the last century, numerous trickling rills and springs disappeared. ' St. Ann's Well,' however, still serves its original purpose : its remarkably pure water is still available free at the picturesque Pump Room, and the surplus water is bottled and has a world-wide reputation for wholesomeness.

II.—*The ' Water Cure '* : 1842–1875.—Contributed by Mr. F. C. Morgan.

The first Hydropathic establishment in England, started by Dr. Graham and Mr. Weiss at Stanstead Bury, Hertford, in 1842, lasted but a few months. The same year, Drs. James Wilson and James Manley Gully came to Malvern. A house on Belle Vue Terrace (the Crown Inn) was bought, re-named ' Gräfenberg House,' opened as a Hydro, and proved a great success. Soon after Dr. Wilson built the present ' Hydropathic Establishment,' and Dr. Gully Tudor House (for ladies) and Holyrood House (for gentlemen), connected by a bridge—called by local wits the ' Bridge of Sighs.' These houses are now the Tudor Hotel. Later on, Gratton House and Malvern House were also built for Dr. Wilson's patients, so popular had the ' Cure ' become. Within a few years rival establishments were started by Dr. Marsden at Peachfield House, Hardwicke, Elmdale House, and North Abbotsford ; by Dr. R. B. Grindrod at Townsend House ; by Dr. Johnson at Malvernbury and Ellerslie House ; by Dr. Ayerst at ' Wells House,' etc. Malvern had entered upon a period of great prosperity and the town grew rapidly.

Many medical authorities, however, attacked the Water Cure system violently, leading to equally violent replies by its supporters, and humorous skits upon the Water Cure poured from the press.

The list of celebrated patients who visited Malvern is long, and includes many leading people in the political and literary world from 1842 to 1870, from which year the era of great prosperity gradually declined. Macaulay, Darwin, Lytton, Charles Reade, and others, testified to benefits received from the treatment, combined with the healthy and beautiful surroundings.

III.—*Wells used Medicinally.*

Chalybeate Spa, ' Pembroke,' Priory Road, Great Malvern.—In 1822 this spring was " up a Cave . . . inclosed by a white railing." Then for many years it was sealed up, but was re-opened in 1924 and a sample of the water taken and analysed. The water is only slightly chalybeate and had to be drunk on the spot, but is recorded to have produced " a slight medicinal effect." The water, when sampled by Mr. Duncan, [1] was disturbed and gave varying figures for iron and other contents.

Hay Well, Great Malvern.—This well is situate just in front of the old Haywell Baths and midway between Messrs. Cox and Painter's premises in Wells Road and the Baptist Church in Abbey Road.

Henry Hillyard, Sanitary Inspector to the Malvern U.D.C. informs me that " In conjunction with the well there are a number of tanks from which a number of the older houses in the vicinity originally obtained their supplies : also, in close proximity to the Hay Well, and under the old building known as the Haywell Baths, there is another well called ' Agnes Well.' It is probable that this well is older than the Hay Well and may have been the source of the domestic supply to the farm buildings which existed on the site of the present Baptist Church."

The Hay Well is supposed to have supplied Malvern Priory and was one of the wells visited daily by the Water Cure patients, who used the waters internally and externally. Baths were built adjoining it in the 19th Century for Dr. Gully's patients.

[1] For analysis see *Proc. Cotteswold Nat. F. Club*, vol. xxii, pt. 3 for 1926 (1927), p. 294.

Tudor Well, Great Malvern.—This well is situate some 50 yards from the Hay Well. It is beneath the buildings known as Tudor Well Buildings, below the Tudor Hotel. Mr. Hillyard has given the following information :—According to information I collected in 1905 from very old inhabitants, this supply was quite accidentally discovered. The cause of my enquiry at the time was an important lawsuit which extended over a period of about three years and was finally decided in the House of Lords, in connection with pipes leading from this well. I here relate some abstracts taken from my brief of evidence, prepared by myself, in connection with the well :—" It would appear that the Tudor Well and building were established at about the commencement of the Crimean War. About this time excavations were made for the purpose of putting down a gas plant wherewith to light some of the establishments in the locality. Whilst excavating was in progress a large spring of water suddenly burst into an opening the workmen were then sinking. The rush of water was so great that pumping operations were for a time resorted to in order to allow the work to be proceeded with. The spring proved to yield a never failing supply of good water and as it so happened that the proprietors of the establishments were having difficulty in obtaining a sufficient water supply thought it well to abandon the gas works in favour of the water and thus the excavations intended for the gas plant were filled in to be water tanks. I think it is probable that the daily flow of water from this source would average not less than 20,000 gallons."

A building was eventually erected over the supply and the buildings known as the Tudor Well Buildings were constructed. Portions of the appliances belonging to the Baths were in existence both at the Tudor Well Baths and the Hay Well Baths a comparatively short time ago.

Miss Waldron's Well, Pomona Place.

St. Ann's Well, Great Malvern.—Messrs, Schweppe Ltd., are now the owners of this famous ' Well.' At the spring is a Pump Room to which the public have free access, the Company collecting and bottling the surplus water. The spring issues from the Malvernian rocks at 820 ft. above O.D. The water is extremely bright and cold. It is claimed to be the purest natural water in the British Isles (Analysis No. 653).

The Holy Well, Malvern Hills, the most famous of Malvern springs, is situate up a valley in the steep side of the Malvern Hills west of St. Peter's Church—above Messrs. J. H. Cuff & Co.'s Holy Well Mineral Water Factory. The source of the water is shallow-seated—from little fissures in the Archaean rocks, from rock-débris in the valley, with doubtless some from the Eye Well that has found its way down through the rock-débris. The spring is now collected near its source to supply a house or two : the overflow runs out of a spout at the back of the factory and some is used to supply the fountain at the factory. The bulk of the water used at the factory comes out of a fissure in the Archaean rocks in the bank south-west of the factory.

The Eye Well, Malvern Wells, is situated by the path-side at a higher level some 200 yards W. by S. of the site of Holy Well. The water oozes out of the Archaean rock, but owing to the path functioning as a dam the ' well ' is now simply a little morass. Arthur Bennett understood from Mr. Wickham that the water was lost in an attempt to lay it on to a private house ; the pickaxe disturbed the rock and the water disappeared.[1] It was the first of the Malvern springs or wells to be mentioned in print (Bannister, 1622).

Ditchford's Well, Little Malvern, was situate some 500 yds. from Little Malvern Church on the west side of the Ledbury road, and about 300 yds. along that road southwards of St. Wulstan's R.C. Chapel. The spring issued from the Malvernian and is said to have attracted attention before the Holy Well, Malvern Wells. Grindrod says in his ' Malvern Past and Present ' (1865), p. 18 :—" An ancient dame on horseback conveyed the water in bottles to Worcester. This spring, also called Mary's and Nancy's Well,

[1] Mr. Bennett says (*in litt.*) :— " Owing to such experiences owners of springs in Malvern are always very careful how they interfere with springs. It is the brashy nature of the Malvern rock which causes such an occurrence."

probably in honour of the female who presided over its fountain, has ceased to exist, or rather is conveyed in another direction."

F. C. Morgan, Public Librarian, Malvern, informs me, however, that he has recently obtained documentary evidence which shows that Ditchford's Well was on the right-hand (or west) side of the road to Ledbury, and Nancy's Well just below it on the left hand side ; but probably both were on the line of the same streamlet.

Walm's Well, Eastnor, Herefordshire.—This spring, just beyond the Worcestershire county boundary, is the source of the Clynch Brook, and now first appears immediately below the west side of the trackway crossing the valley that descends south-westwards from near Clutter's Cave, and lies between Hangman's Hill and the Herefordshire Beacon. The bulk of the water appears to drain from off the Archaean rocks of the hollow, but it may be in part a fault-spring, for it is very near to the western boundary fault. It may have been the principal source of supply to the British Camp which crowns the Herefordshire Beacon. Dr. C. Hastings in his " Illustrations of the Natural History of Worcestershire " (1834), p. 117 says that the water was held to be more efficaceous in the cure of skin diseases than the waters of St. Ann's and Holy Wells. There used to be a bath and a wooden hut for bathers. Edwin Lees,[1] speaks of " a clear but small piece of water, called Walm's Well," but the piece of water, bath—except for some of the stonework still to be seen in 1924—and hut have long since disappeared.

Pewtriss (Putress or Putriss) or Prime's Well.—This fine spring (see p. 117) issues on the western boundary-fault on the north side of the Ledbury road in Herefordshire a short distance westwards of the British Camp Hotel, and during the shortage of the Public Supply to Malvern in 1903–5 water was pumped from it into The Camp Reservoir. The water runs over a little waterfall and down a gorge, and finally, at a distance of only about 100 yards from its outburst, sinks into the Wenlock Limestone and is lost. Allan H. Bright, of Barton Court, Colwall, claims that it is the brook mentioned by William Langland or Langley in " The Vision of William concerning Piers the Plowman . . ." (earliest draft about 1362), and that the latter was a Colwall man, the supposed site of his residence being where the ' Stone Cottages ' now stand—the first cottages on the left after passing over the railway-bridge below Chance's Pitch.

Mooral's or Moorally Well lies near Linden in Colwall parish, Herefordshire, about three-quarters of a mile south-south-west of the Wyche Cutting. Arthur Bennett thinks it springs from a little above the western boundary-fault. There used to be a cottage and a bath ' lined with bricks ' ; but Chambers, writing in 1817, says that it was then quite out of repair and that the owner contemplated restoring it—an intention that did not mature.

Public Water Supply

Particulars concerning the Malvern Urban District Council's water-undertaking are thus summarized in the Return as to Water Undertakings in England and Wales (1915), pp. 88, 89 (Local Government Board) :— " [Council's undertaking] supplies Malvern U.D. (part) ; and parts of parishes of Colwall (Ledbury R.D.) and Guarlford (Upton-on-Severn R.D.) ; and furnishes a supply in bulk to Newent R.D.C.

Powers.—Malvern Improvement Act., 1851 ; Malvern Water Acts, 1891 and 1905 ; Malvern Link (Extension and Water)Act, 1896.

Limits.—Malvern U.D., and parishes of Colwall, Mathon Rural (Ledbury R.D.) ; Leigh (Martley R.D.) ; Madresfield, Newland (Upton-on-Severn R.D.).

Sources of Supply (Nature and Sufficiency).—(1) Upland surface and springs from gneiss and granite, Malvern Hills ; (2) Boreholes in New Red Sandstone, Bromsberrow Heath, Dymock, Herefordshire [2] ; (3) Borehole (p. 125) at the Gas Works, Malvern Link (emergency supply). The daily

[1] *Loc. cit.*

[2] The Waterworks are in Bromsberrow parish.

average quantity of water available from each source is, respectively, (1) 363,600 gallons ; (2) 900,000 gallons ; and (3) 100,000 gallons.

Works.—Filtration, 350 gallons per square yard per day. Storage reservoir :—British Camp, 50, 780,000 gallons. Service reservoirs :—British Camp, 250,000 gallons ; [Lower] Wyche, 780,000 gallons ; Upper Wyche,[1] 150,000 gallons ; North Malvern, 750,000 gallons ; Haysladd,[2] 100,000 gallons [120,000 gallons]. Pressure is sufficient.

Quantity of Water supplied.—The daily average is 347,400 gallons, and 1,200 in bulk. Supply is constant.

Quality of Water.—Fortnightly chemical and bacteriological examination. Analyst remarks (20th December, 1913) that the water is very good. Hardness :—total, 3.3° ; permanent, 1.8°. No action on lead."

Historical Retrospect.—The District, now the Malvern Urban District, was originally supplied by wells, mostly shallow, and springs.

In 1835 Charles Morris had constructed, at his own expense, a tank (of 50,000 gallons capacity) at North Malvern, intended mainly for the use of the poor of the neighbourhood. As this proved inadequate he had another tank constructed, of similar capacity, in 1836, adding in 1843 a tower. In 1840 he had constructed a tank at the Lower Wyche, a little southwards of the Council's present Lower Wyche reservoir, and, in 1844, one at West Malvern.

In 1844 steam-power had to be resorted to at Barnard's Green Mill owing to the water-supply diminishing.

In 1851 the Malvern Water Act was obtained. Locally, in 1855, awkward shortage resulted owing to water from the Valley springs being taken for Hydropathic establishments.

In 1864 a long compensation case, Bullock v. the Town Commissioners took place owing to the alleged diversion and tapping of springs in the Rushey Green, Little, Wide, and Firs Valleys, causing insufficient supplies, for mill purposes, and damages were obtained against the Council.

In the same year, fourteen doctors presented a petition to the Town Commissioners drawing attention to the inadequate supplies, and statistics of the water supply were published in the " Advertiser " for July 1st and 8th, 1865, by Dr. Johnson. In 1866 the shortage was still so acute that a discussion ensued as to whether it would not be better to have earth-closets in place of water-closets. Mr. Bovill was called in to report on the position and recommended either an artesian well or an impounding reservoir at the foot of the Rushy Valley, but both schemes were turned down on the score of expense.

In 1867 Edward Wilson reported and recommended an artesian well. The scheme was adopted ; but was subsequently rejected by the Commissioners in view of the cost.

In 1868 J. F. Bateman was engaged by the Commissioners to go into the matter. He made three suggestions—a reservoir at the British Camp, pumping from the River Teme, and an artesian well in the New Red Sandstone. All three were rejected at a town's meeting owing to the expense. A second drinking-fountain was opened about this time at The Wyche Institute, and one—the gift of Major Ward Jackson—between Abbey Villa and Wellington House. The latter, together with the private supply to the Major's and several other houses lower down, gave out when the Commissioners sunk a well for the town's use higher up the hill.

In 1870, the Royal Well (18,080 gallons per day)—the gift of W.H. Ryland—was opened near the Wyche. In 1871 two Local Government Inquiries were held concerning the town's supply. In 1872 a large reservoir was constructed at North Malvern ; but this—really an enlargement of Morris's tank—entirely collapsed during re-construction and had to be rebuilt in 1874–75. About 1876 the Lower Wyche reservoir was constructed. In 1887 there was a great drought, and in 1888 the Town Surveyor reported

[1] Completed, with a Pumping Station and extension of mains, in 1897.

[2] Constructed at the Haysladd Spring and about 16 miles of cast-iron water-mains laid through West Malvern and the Link during 1898.

in favour of a large reservoir on the Wells Common. This report was supported by Prof. Pole. Another expert suggested a reservoir at Hill Farm, Malvern Wells. Mr. Mansergh's plan of sinking a number of shafts was adopted, but could not be proceeded with as the site proposed for the reservoir could not be acquired.

In 1890 a public meeting approved Mr. Copeland's scheme for a reservoir at the British Camp. The work was commenced in 1892 and opened by the Duchess of Teck in 1895. The following notes on this scheme and the subsequent history of Malvern water-supply are largely quoted from a paper by Wm. Osborne Thorp.[1] "The scheme in question consisted of the construction of a large catchment reservoir formed in a natural hollow or valley, beautifully situated below the British Camp Hill or Herefordshire Beacon 4½ miles south of Great Malvern.

" An earth dam, with puddle trench of the usual type, was thrown across the valley; and the reservoir thus made was in the form of an inverted cone, which, when full, had a capacity of 44½ million gallons.

" The ordnance-datum of the top water level was 667 feet; the reservoir being purposely kept at a high elevation to permit of water being delivered to the greater portion of Great Malvern by gravitation. The gathering area around the basin forming the storage reservoir was naturally very small, and this was augmented by the provision of catchment drains laid on the eastern slopes of the North Hill and Worcestershire Beacon. These averaged 4 to 5 feet deep, and consisted of stoneware pipes laid in trenches with open joints, the bottom half being encased in puddle, and the trench above the pipes filled in with loose stone, so that the rainfall flowing down the slopes of the hills over the hard syenite [granite] rocks would be intercepted. As some of these catch-waters were between four and five miles from the reservoir, which was itself situated at a high level, their gathering area was, of course, of limited extent—the total being only some 387 acres. The catch-water drains discharged into a 15-inch cast-iron main which carried the water through Malvern and Malvern Wells under pressure to the main reservoir.

" Two filter-beds were provided, each 55 feet by 50 feet in plan; and the clarified water conveyed therefrom into an open service reservoir 90 feet in diameter and 12 feet deep. From this the water was actually brought back into the 15-inch main which carried the unfiltered water from the catch-waters to the storage, and was so conveyed to the town and distributed in the service mains. Needless to say, this ingenious and economical idea was not a success; and shortly after the arrival of my predecessor Mr. [now Sir] H. P. Maybury, a 10-inch independent supply main, for the filtered water, was constructed from the Camp reservoir. Thanks to a wet season, the reservoir was opened in 1894 brim full.

" The population within the area of the then Great Malvern Local Board was just over 8,000. The consumption at that time, according to the meters, was about 140,000 gallons per day; and until the year 1902, though the reservoir at times ran perilously low, a wet season seems to have occurred just at the psychological moment to avert a water famine, and no serious trouble had arisen.

" In 1896, the adjoining Local Board of Malvern Link, which had a population of about 6,000, were in difficulties about water supply, and obtained parliamentary powers to take certain springs and construct catch-water drains on the western slopes of the hills, and convey the water to a large reservoir at Parkwood, West Malvern. As works of sewerage and other expensive undertakings were looming in the immediate future, the Malvern Link and West Malvern districts were amalgamated with Great Malvern, which had just previously absorbed Malvern Wells. With the population more than doubled, an augmentation of the water supply had to be provided without delay.

" The Council immediately put into force the powers given them under the Malvern Link Water Act and constructed [during 1898] the Haysladd

[1] *Trans. Assoc.* (now *Inst.*) *Water Eng.* vol. xii, 1907, p. 274.

service reservoir, fed by the spring of that name, for the supply of the upper part of West Malvern. Catchwater drains similar to those laid on the east side of the hill were carried out ; but instead of constructing the Parkwood Reservoir, a 12-inch cast-iron main was carried through the Wyche Cutting to the eastern side, and connected with the existing 15-inch main, so that the whole of the hill water collected in this manner was conveyed to the Camp reservoir, and the Great Malvern service mains were then extended to supply Malvern Link. The discharge from the catchwaters on the west side of the hills is metered at the Wyche Cutting, and the average amount collected by this means, from 200 acres, averaged only 30,000 gallons per day taken over a period of eight years.

" The following table shows the rainfall and the yield from the west side of the hills :—

Year.		Rainfall.		Water obtained from West Side.
		Inches.		Gallons.
1899	...	23.4	...	8,947,000
1900	...	28.8	...	9,001,000
1901	...	21.2	...	6,100,000
1902	...	24.9	...	7,176,000
1903	...	37.1	...	25,805,000
1904	...	22.6	...	11,497,000
1905	...	28.0	...	3,333,000
1906	...	28.3	...	8,110,000
	Average	26.8		9,996,000

" . . During the past seven years the yield from both sides of the hill (587 acres) averaged but 174,000 gallons per day, equal to 4¾ inches out of an annual rainfall of 26¾ inches for this period. A careful examination of records makes it evident that the rainfall from April to the middle of September is useless for waterworks purposes, and that a year with average rainfall, an undue proportion of which fell in the summer, would mean a serious deficit in the water received. This is doubtless due to the exposed position of the hills, which are subject to the uninterrupted heat of the sun upon a thin covering of fine turf overlying the rocks, and also the evaporative power of the winds from all quarters. More important still is the face of the rock which (as revealed in all quarries) contains large and extensive fissures, and to these must be attributed the failure of the catchwater drains."

During the dry period of 1902 the reservoir was depleted to such an alarming rate that every available spring, well and stream, had to be pumped into the mains.

" Fortunately the rains set in early in September, 1902, and with the wet year of 1903 converted an empty reservoir into a full one for the first time since the opening year. To increase the storage, the earth and puddle dam at the Camp reservoir was raised 3 feet (quite up to its limit of safety), which increased the storage from 44½ millions to 50¾ million gallons, and an additional filter-bed was constructed. The Council, however, recognised that further water-works were necessary, and a borehole was sunk by Mr. Maybury on land adjoining the Link Gas-Works during 19[02–]03. This borehole, 8 inches in diameter, was sunk through exceedingly hard marl with gypsum into the new red [Lower Keuper] Sandstone—the total depth being 878 feet. The pumps were placed at the bottom of a well 200 feet deep, and 12 feet in diameter ; the water being raised to a surface tank, from whence it was driven to the North Malvern service reservoir, a distance of two miles, with a lift of 480 feet. . . .

" This work had just been completed when the author [W. O. Thorp] took over his duties in June, 1904, at which time a severe drought occurred,

following the wet season of 1903. Although the reservoir was full at the end of March, by the end of November, 1904, it was quite empty, in which condition it remained till the end of February, 1905. In the month of August, 1904, so rapid was the depletion, that the new borehole pumps were set to work ; but the result was very disappointing, as, instead of yielding 225,000 gallons daily as anticipated, not more than 100,000 gallons could be pumped in 24 hours. In October, there being no sign of the hoped-for autumnal rains, all the temporary sources of supply were put into use, but these were not sufficient to stem the tide which was rapidly ebbing from the Camp reservoir." [1]

A small estate of 52 acres, known as the Grove House Farm, Bromsberrow Heath (to the south of the south end of the Malvern Hills), was bought with the object of boring there at once in the Bunter Sandstone ; but difficulties with the Local Government Board retarded matters. Mr. Thorp recommended sinking a large borehole at Malvern Link Gasworks and that in the meantime an attempt should be made to increase the quantity obtained from the 8-inch borehole by the use of compressed air.

" Messrs. C. Isler and Co. were entrusted with the sinking of a 12-inch borehole to a depth of 950 feet, lined to a depth of 710 feet, for the sum of £1,790, and it was hoped this would be completed, by working continuously with three shifts per day, within six months. An agreement was also entered into with the same firm for the supply and working of an air-lift pump in place of the existing deep-well pumps. A 14-inch by 14-inch by 18-inch stream-driven compressor was fixed, by which some 170,000 gallons of water per 24 hours were raised ; the water-level falling to 320 feet below the surface. It was found necessary to keep this plant running for nearly ten months ; and with water obtained from numerous little pumping-stations, a supply of about 230,000 gallons per day was maintained throughout 1905." [2]

By July, 1905, Parliamentary powers were obtained to commence work at Bromsberrow Heath.

" At the Link borehole the Contractors met with many difficulties, owing to the nature of the marl, which contained beds of gypsum and pieces of rock which had no doubt drifted down from the Malvern Hills ; and, in spite of all efforts, it was impossible to complete the boring in time for it to be of service for the summer months." [3]

The tool became jammed at 740 feet and a cast iron connecting piece had to be bored through. The remaining 200 feet was completed within a month, but the summer being practically over and the construction of the permanent works at Bromsberrow well in hand, no further steps were taken towards putting the borehole into practical use. A section of the strata penetrated by this borehole is given below.

" After the passing of the Water Bill [July, 1905], two boreholes were driven at Bromsberrow to a depth of 200 feet in the new red [Bunter] sandstone, 40 feet apart and 15½ inches in diameter, which on being tested gave a yield of nearly 900,000 gallons per day. The water level was 33 feet from the surface to commence with, and was only lowered 8 feet during 14 days' pumping, and it was therefore decided to immediately proceed with the works." [4]

The pipe-track from Bromsberrow follows the eastern side of the hills, running due north—the total distance being 5¾ miles. The pipes are 10 inches in diameter. The mains are so arranged that on the water arriving at The Camp Reservoir, it can be passed into the large storage reservoir or sent direct into the service reservoir below. Automatic back-pressure valves are provided at various points and these are bye-passed with 3-inch pipes, to permit of the supply to any district or houses en route being maintained from The Camp Reservoir when the pumps are not working at Bromsberrow.

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[1] Thorp, W. O., *Trans. Assoc.* (now *Inst.*) *Water Eng.*, vol. xii, 1907, pp. 278–279.
[2] *Ibid.*, p. 280.
[3] *Ibid.*, p. 281.
[4] *Ibid.*, p. 285.

Boring [1] at The Gas Works, Malvern Link

Made in 1905 by Messrs. C. Isler and Co., Ltd. Full record published by W. O. Thorp [2]; the following is a condensed version :—

		Thickness Ft.	Depth Ft.
Keuper Marl	Soil	2	2
	Red marl	124¾	126¾
	Blue arenaceous shale with gypsum ...	4	130¾
	Red and blue mottled marl, alternating with 7 bands (two called 'compact') of blue arenaceous shale, which vary from 2 ft. to 7 ft. in thickness; the whole with gypsum	302¼	433
	Red and blue mottled marl, alternating with beds of blue arenaceous shale, with much gypsum	182	615
	Red and blue mottled marl, alternating with beds of blue arenaceous shale and thin layers of red sandstone towards the bottom and no gypsum	90	705
Lower Keuper Sandstone	Red sandstone with water	36	741
	Red marl	16	757
	Red sandstone with water	193	950

Yield.—With water-level at 200 ft. below surface— 90,000 gallons per 24 hrs.
,, ,, ,, ,, 300 ft. ,, ,, 160,000 ,, ,, ,, ,,

The rest-level is within 20 ft. of the surface, but very rapidly drops on pumping to levels depending on the quantity pumped, and is not restored to normal until about 10 hours after pumping has ceased. Mr. Thorp informs me that the sandstone, at the great depth at which it is found in this boring, is exceedingly close in grain and the amount of percolation small.

Minor Supplies

Happy Valley.—Several small springs in this Valley are collected into small tanks and supply Aldwin Towers and a few houses in the vicinity. Some other houses are similarly supplied from small springs in Rushy Valley.

Wyche Cutting.—A small tank, constructed in 1904 just north of this Cutting, originally had water pumped to it from a well on the Wells Common close to the railway; but the well was abandoned, as the water feeding it was surface-water, and the small tank is now utilised for distribution purposes from the town mains.

Almost directly above the Malvern Tunnel is a tank which formerly received water from springs in the tunnel and supplied several houses. Mr. C. C. Duncan informs me that this water would appear to come from near the western end where Silurian beds are faulted against the Archaean. The little pumping-station, which was in the tunnel, has now been done away with and the Railway Company has laid on town water to the houses concerned. The water from the springs in the tunnel now gravitates to tanks at Malvern Wells, Great Malvern, and Malvern Link Stations and is used for purposes other than drinking.

West Malvern.—On the edge of the common eastward of St. James's Church and near the Westminster Hotel is a reservoir, catching hill-water, with a good overflow. It supplies some seven or eight houses belonging to St. James's School and until about eight years ago supplied the School also. Several small tanks are connected with the Supply.

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[1] Second boring 12-in. diameter; the journal of the first boring, 1902–03, 8-in. diameter, 878 ft. 2 in. deep, is identical, except that the bottom item is 121 ft. 2 in. thick. For a note of the first boring and further particulars of the second boring, see above, pp. 123, 124.

[2] *Op. cit.*, p. 284.

A well and boring at West Malvern were recorded by G. E. Mackie [1] and again noted by Prof. T. T. Groom.[2] The site [3] is close to the old or lower road round the north end of the hill, 300 yds. S.S.W. of Cowleigh Park Farm, and just below the 600-ft. contour. The well which started in 12 ft. of hill-debris, was sunk through May Hill Sandstone and conglomerate, and a fault (at 58 ft. down) into black Cambrian shales (depth 67 ft.) below which a boring penetrated 9 ft. more of black shales, followed by another fault and 13 ft. of red rocks (supposed to be a repetition of May Hill Sandstone). The dip was 50°. The yield of water is not recorded.

North Bromsgrove Urban District.—Maps : 168, 182, 183 ; 54 N.W. ; 10 N.W., S.W., 15 S.W., N.E., S.E., 16 N.W., S.W., 22 N.E., 23 N.W.

This is a large Urban District—10,592 acres. It extends from a point east of Romsley southwards to the Bromsgrove U.D. and has a detached portion adjacent to that District on the south. Eastwards it extends to Barnt Green, and westwards to Woodcote Green. It therefore includes the depression-separated hills—formed of Trappoid Breccia succeeded by the Pebble Beds of the Bunter—situate between the Lickey and Clent Hills, with the lower ground to the north (the southern extremity of the South Staffordshire Coalfield) and the broken country to the south (gradually declining, owing to the dip of the beds) on the Upper Mottled Sandstone and succeeding Keuper. These Keuper Beds are the Lower Sandstone and the Marl, but are separated from each other by a fault. At Barnt Green House the District boundary takes in a small tract of Archaean rocks.

The more populous parts of the District, such as Rubery, Barnt Green, Blackwell, and Bourn Heath have the East Worcestershire W. Co.'s water laid on : houses at other places have wells and a few are dependent on springs. At Great Dodford, which is on Keuper Marl, Thos. Jones, Inspector and Surveyor to the District Council, informs me that the wells are up to 60 ft. in depth : at Alfred's Well (on an old map ' Offad's Well,' and, in an old document, ' Holdford '), which is on the Keuper Sandstone, they are from 8 to 36 ft. (according to the elevation), and yield good water.

Springs used for supply are such as those at Lickey Rock on the Pebble Beds (by the roadside and bricked up), and at Little Heath (small and open). Spring water is forced up by ram to supply Fockbury Farm and buildings, and water from the Salwarpe is raised by ram to a reservoir whence it gravitates back to supply Chadwick Manor House farm buildings with water for the cattle. A windpump raises water from the head spring of the Salwarpe to supply the house called ' Heanor ' on the western slope of Beadon Hill, Upper Lickey Hills ; another at Whelty Bridge, near by, merely lifts, from a tank to Holywell Farm, water supplied from the Company's reservoir.

Holy Well is a shallow dip-well (marked as chalybeate on the six-inch map) fed by a spring issuing in Keele Beds ground (Coal Measures). The overflow runs into a small ill-kept pond, thence into the wood and so on to the Salwarpe, which is impounded to form the Chadwick Pools.

The District is well supplied with streams, fed by springs which are—Mr. Jones informs me—mostly perennial and were not affected by the drought of 1921.

The occurrence of water in the Pebble Beds is somewhat capricious in the higher regions—as around Bankhouse Farm ; but in the lower-lying parts these beds and the succeeding Upper Mottled and Lower Keuper Sandstones are full of water and the water-table rises and falls noticeably in places. Mr. Jones informs me that water " boils up " at times through a fissure in the Keuper Sandstone (close to where the Marls are faulted against it) near the bridge at Alfred's Well : also, that when the Company commenced pumping from their boreholes in the basal Keuper Sandstone and Bunter at Catshill

[1] *Mid. Nat.*, vol. x, 1887, p. 197.
[2] *Quart. Journ. Geol. Soc.*, vol. lvi, 1900, pp. 157–158.
[3] As marked on map (plate viii) accompanying the paper last quoted.

the private wells in the Bourn Heath district were almost immediately drained by the lowering of the water-level. S. H. Loynes, Kidderminster, has also noted pumping interference at Lickey End, through which flowed the Spadesbourne Brook, which rises near the Mearse, near Lickey Grange. This stream fed the ponds which supplied the power for Crow's Mill and Townsend Mill, and before the borings were made by the East Worcestershire W. Co. at Burcot was always a good stream ; but since they were put down its flow has been much reduced—it is now really about one half, or in dry seasons about one third, of what it was formerly.

BORING AT BARNSLEY HALL MENTAL HOSPITAL

Made in 1903 by Messrs. E. Timmins & Sons, Ltd., Runcorn, and particulars communicated by A. Thornley, formerly Deputy Clerk to the Worcestershire County Council.

	Thickness Ft.	Depth Ft.		Thickness Ft.	Depth Ft.
Shaft (diameter 12 ft.) :—			Rock	10	60
Soil	2	2	Rough rock... ...	6	66
Sand	1	3	Marl	40	106
Rocky marl	4	7	Sand	26	132
Rock	5	12	Marl	26	158
Clay	2	14	Sandstone	170	328
Borehole :—			Conglomerate ...	16	344
Clay	32	46	Clay	4	348
Sand (with water) ...	4	50	Sand	2	350

[Upper Mottled Sandstone from 2 to 158 ft. ; below that, Pebble Beds].

After pumping 4½ hours at the rate of over 7,000 gallons per hour the water-level fell to 40 ft. ex surface ; after 24 hours pumping it stood at 51 ft. ex surface.

A second boring was made to the Conglomerate at a depth of 341 ft. ; the remaining 9 ft. contracted for were not insisted on, as drills would have been necessary owing to hardness.

Oldbury.—Maps : 168 ; 62 S.W. ; 2 S.W., 5 N.W., N.E.

This Urban District embraces the two civil parishes of Oldbury and Warley. The greater part is on Coal Measures (which rest on Silurian strata ranging from the Llandovery in the east to the Ludlow in the west [1]) ; but marls, sandstones and thin breccias from 75 to 200 ft. thick (? Upper Coal Measures) floor the Warley area [2] and are succeeded on the east unconformably by the Bunter Pebble Beds. Locally, these formations are covered with Drift.

The majority of the houses have the South Staffordshire W. Co.'s water laid on ; but there are standposts, and many individual properties are served wholly by one standpost. The Company has a reservoir at Bristnall-hall Road, Warley (1,000,000 gallons). E. Harrold, Sanitary Inspector, informs me that there are roughly 40 to 50 wells in use (for drinking-purposes) in the District. Between 1920 and 1924 some 25 to 30 were closed, not because of actual pollution, but because the owners had to convert privy closets into water closets. In every case taps were also provided. Mr. Harrold says that since 1915, 723 houses have been connected with the Company's mains. The only springs he knows of in the District from which water is taken for drinking purposes are :—

1. Lime-pit Bank Spring near the boundary 1⅛ miles S.W. by 5°S. of Oldbury Church, which supplies water to Lime Kiln Cottages, Birchfield Lane, Oldbury ;

[1] See map by W. Wickham King, *Trans. Inst. Min. Eng.*, vol. lxi, pt. 5, 1921, p. 159.
[2] King, W. Wickham, *Quart. Journ. Geol. Soc.*, vol. lv, 1899, pp. 115–118.

2. At 95 St. James' Road, Rounds Green, 15/16ths mile W. of Oldbury Church ;

and useful springs from the Trappoid or Clent Breccia in the Enville Beds running to waste :—

1. Known as ' Towny Brook,' situate in Brand Hall Lane, Warley, the outfall of which is into a brook running near by ;
2. In the fields lying between Vicarage Road, Langley, and Bristnall-hall Road, Warley.

Oldbury Borings

1.—*Crosswells Brewery, Langley (Messrs. Showells, Ltd.)*

Completed Nov. 24th 1899. Particulars [here condensed] from Messrs. C. Isler & Co., Ltd. Classification of the beds by W. Wickham King.

	Thickness Ft.	Depth Ft.		Thickness Ft.	Depth Ft.
Shaft :—			Sandy marl	5	55
Red sandstone ...	11½	11½	Conglomerate ...	1½	56½
Borehole :—			Alternations of clay,		
Sand and rock ...	12½	24	rock and sandstone	253¼	309¾
Running sand ...	3	27	Alternations of marl,		
Conglomerate rock	6	33	rock and hard rock,		
Clay	10⅚	43⅚	with some clay near		
Conglomerate rock	6⅙	50	the top	288	597¾

[Drift to 27 ft. ; Enville Conglomerates A^1—A^2 (27 to 56 ft. ; remainder Keele Beds].

Lined with :—

9 ft. of 24-in. tubes, top at 11 ft. below surface
30 ,, ,, 20-in. ,, ,, ,, 3 ft. ,, ,,
102½ ,, ,, 15-in. ,, ,, ,, 251 ft. ,, ,, (perforated)
202 ,, ,, 11-in. ,, ,, ,, 331 ft. ,, ,,
31 ,, ,, 8½-in. ,, ,, ,, 516 ft. ,, ,,

Rest-level.—38 ft. ex surface. Supply.—6,000 gallons per hour.

2.—*Messrs. Albright & Wilson, Ltd. (Trinity Street, Oldbury)*

Made and particulars communicated by Messrs. C. Isler & Co., Ltd.

No. 1.	Thickness Ft.	Depth Ft.		Thickness Ft.	Depth Ft.
Borehole :—					
1. Red marl	4	4	7. Loamy marl	4	73
2. Red marl and pebbles	3	7	8. White sandstone ...	3	76
3. Pebbles	4	11	9. Red marl ...	44	120
4. Red marl	29	40	10. Red marl ...	10	130
5. Red sandstone ...	21	61	11. Limestone ...	29	159
6. Grey sandstone ...	8	69	12. Hard marl ...	9 7/12	168 7/12

Water-level.—Standing, 22 ft. ex surface. Supply.—12,000 gallons per hour. Lines with 40 ft. of 10-in. tubes.

Of No. 1 Borehole section W. Wickham King remarks (*in litt.*) : " It is close to or on the Eastern Boundary Fault. I cannot tell what the beds were ; but beds 1 to 5 may be Keele Beds, 6 to 10 ? Coal Measures, and 11 possibly Silurian, which at a pit to the south was pierced."

No. 2.	Thickness Ft.	Depth Ft.
Dug Well	4	4
Borehole :—		
Red marl and pebbles	3	7
Pebbles	4	11
Red marl	33	44
Red sandstone	11	55

Lined with 40 ft. of 10-in. tubes. Water-level.—24 ft. 6 in. ex surface. Supply.—7,500 gallons per hour.

Redditch.—Maps : 183 ; 54 N.W. ; 23 N.E., S.E.

Redditch is on the red Keuper Marl on the surface of which are, locally, deposits of gravel (Drift).

W. Jameson, the Sanitary Inspector to the Urban District Council, informs me that of the 3,829 houses, 3,820 have a piped supply from the East Worcestershire W. Co. Water is laid on from the Headless Cross reservoir ; but this is only used for emergency or when repairs are carried out. In general, Redditch and Headless Cross, which is within the Urban District area, have a continuous supply of water from the mains. The average number of gallons consumed per day is 790,772.

Previous to the introduction of the Company's water, Redditch was dependent on private wells, the supply from which, C. E. de Rance said, was bad.[1]

Stourbridge.—Maps : 167 ; 54 N.W. ; 4 S.W., 9 N.W.

This Borough spreads over Lower Pebble Beds, Upper Mottled Sandstone, Lower Keuper Sandstone, Trappoid Breccia and Coal Measures. The Triassic rocks have a prevalent easterly dip towards the Western Boundary Fault of the South Staffordshire Coalfield, which brings the other older rocks to the surface.[2]

Below the Pebble Beds west of the fault is the Lower Mottled Sandstone, and the older rocks below this, reposing in turn on Downtonian, form part of a Palaeozoic sub-Triassic floor which W. Wickham King has proved to have a general slope south-south-eastwards. The Triassic rocks are very porous and, in consequence, full of water, which to a considerable extent is impounded in them by the Coal Measures against which they abut. W. Wickham King has communicated the bore record given below, and the remarks on the Stourbridge basin which follow.

STOURBRIDGE BORINGS

1.—*Boring at Kingswinford Workhouse*

Made June to October, 1911. Particulars communicated by C. F. E. Griffiths, M.E.

	Thickness Ft.	Depth Ft.		Thickness Ft.	Depth Ft.
Old well	—	111	Marl rock	7	184
Borehole :—			Soft red sandstone ...	9½	193½
Hard red sandstone	18	129	Hard do. do. ...	5	198½
Conglomerate ...	6¾	135¾	Soft do. do. ...	16	214½
Hard red sandstone	4¾	140½	Soft do. do. ...	20	234½
Soft do. do. ...	7	147½	Soft do. do. ...	2½	237
Hard do. do. ...	6½	154	Pebbles and hard sand	6	243
Very soft do. do.	¾	154¾	Red sandstone ...	14½	257½
Hard do. do. ...	5¾	160½	Catbrain conglomerate	5½	263
Catbrain, very hard	4	164½	Hard red sandstone ...	17	280
Marl rock	6	170½	Hard marl rock ...	31	311
Soft red sandstone	6½	177	Hard marl rock ...	4¾	315¾

The last 35 ft. 9 in. fell in and filled up the bottom part of the borehole.

" I did not know of this boring, for 280 ft. in the Middle Bunter, until 1914. The last 35 ft. 9 in. cannot be either Middle or Lower Bunter. A fault was passed through here and the bottom part of the bore was in the highest beds of the Trappoid Breccias (? Permian). In 1915 I shewed to Mr.

[1] ' The Water Supply of England and Wales,' 1882, p. 369.

[2] See sketch map in ' The Southern Part of the South Staffordshire Coalfield ' (*Mem. Geol. Surv.*), 1927, Plate II ; this work also gives an account of the geology of the district.

Griffiths the Breccia cores from the bottom parts of the G.W.R. Goods Station borehole [see p. 132] and he recognised them as identical with the lowest rocks pierced at the Workhouse." The Engineer at the Workhouse also, who had seen all the material out of the boring, from a number of specimens of various different types shown to him picked out one fragment (taken from the Trappoid Breccia core in the G.W.R. boring), as representative of the lowest 35 ft. 9 in. in the Workhouse boring.

" The Stourbridge basin can be defined—Mr. F. G. Meacham told me that the Trappoid Breccias have been found in wells about 100 ft. deep at Wallheath, 1½ mile N.W. of the Workhouse. In High Street, Wallheath, the surface is 255 ft. above sea-level and so the top of the Breccia is here say 150 ft. above sea-level. The surface at the Workhouse borehole is 300 ft. and the Breccia 20 ft. above sea-level. The surface at the G.W.R. Goods Station boring is about 230 ft. and the top of the Breccia is 615 ft. *below* sea-level. This Goods Station is 2 miles S.S.E. of the Workhouse. The deep Stourbridge basin slopes to the S.S.E., so that in 3½ miles the Trappoid Breccia dips from 150 ft. above sea-level to 615 ft. below sea-level. The southern limit of the basin is difficult to locate, but appears to be the broken physiographical E.—W. ridge from the south side of Wychbury Hill to the Birches, Hagley, and thence to Iverley Hill. The western edge of the basin is bounded by the Stapenhill fault, downthrow to west, which runs along a S.—N. line from Bunkers Hill, Iverley, to Wallheath. There is a steep slope W. to E. from Wollaston ridge to the Goods Station borehole. The E.N.E. side of the basin is bounded by the western faults of the South Staffordshire Coalfield. Mr. William Fiddian states that the come of water at the Stourbridge Waterworks boreholes is much greater than this watershed would afford and so one must look outside the basin for further supplies. There are streams which start on the slopes of Wychbury over clay ground, into the Stourbridge basin of Triassic sandstone. In the clay ground the streams are cut deep, indicating that not much water sinks in ; whilst directly these streams reach the Triassic sandstone they are not deep cut as if much water sank. The River Stour also crosses the Stourbridge basin. There is also another possible source. Large quantities of water flow down to the western fault of the South Staffordshire Coalfield along the Brockmore fault and the Corbyns Hall fault. The Thick Coal has been worked at 447 ft. and 382 ft. below sea-level, where these faults join up with the Western faults, and on the downcast side of the Western faults the Bunter Conglomerate or Upper Bunter crops out at about 300 ft. O.D. or less. In the G.W.R. Goods Station boring the Upper Bunter was passed through for 206 ft. and the Bunter Conglomerate and Lower Bunter were 639 ft. thick. So as the Trias is on a level with the Thick Coal it is possible that the water flowing to the S.W. along the Brockmore and Corbyns Hall faults might cross the Western faults and get into the Stourbridge basin ; for it is well known that faults in the Bunter sandstones do not stop the flow of water. As, however, there is a thin strip of the Trappoid Breccia in one of the steps of the Western boundary faults, the marly nature of these beds might possibly hold up these waters to some extent. It is significant that in the parts of the Western faults referred to there are very few springs indicating that the Brockmore and Corbyns Hall waters do percolate downwards through the New Red (Trias)."

Stourbridge Borough is supplied by the Stourbridge and District Water Board, who took over the Stourbridge Waterworks Company on January 1st, 1910.

Arthur Kent, Sanitary Inspector, Borough of Stourbridge, informs me : " [The water supply] is adequate for all requirements and is pumped direct into the mains from the two deep wells which are situate at Coalbournbrook and Mill Meadow respectively, both being in Amblecote.

" A Reservoir at Doctor's Hill in the Borough, serves to augment the pressure, the surplus water during the night going into the Reservoir. The supply is constant. All the houses have galvanised iron supply pipes.

" There are still a few houses procuring their water supply from pump wells. A considerable number of the houses supplement the water supply by having rain water cisterns on their premises."

2.—*Boring at Corporation Baths, Stourbridge*

Made and particulars communicated by Messrs. C. Isler & Co., Ltd.

	Thickness Ft.	Depth Ft.
Dug well	10	10
Borehole :—		
Sandstone [U. Mottled] ...	245	255

Tubes.—60 ft. ; top 5 ft. below surface. Rest-level.—26 ft. ex surface. Yield.—5,400 gallons per hour.

3.—*Boring at Stourbridge Gas Works, Staffs.*

Made and particulars communicated by Messrs. C. Isler & Co., Ltd. Surface-level.—About 230·6 ft. above O.D.

	Thickness Ft.	Depth Ft.
Dug well	24	24
Borehole :		
Sandstone [U. Mottled], hard ...	191	215

Tubes.—10 ft. × 8½ in. tubes top 21 ft. below surface. Rest-level.—23 ft. ex surface. Yield.—6,000 gallons per hour (minimum).

4.—*North Worcester Brewery Co., Duke Street, Stourbridge*

(Passed out of existence about 1908 ; Premises now owned by A. Harris)

Made and particulars communicated by Messrs. C. Isler & Co., Ltd.

		Thickness Ft.	Depth Ft.
Dug well		39	39
Borehole :			
[Upper Mottled Sandstone]	1. Sandstone	211	250
	2. Loamy marl	5	255

Tubes.—80 ft. × 11½ in. tubes top 38 ft. 3 in. below surface. Rest-level.—41 ft. ex surface. Supply.—8,000 gallons per hour.

Mr. Cleverly informs me :—" As far as I have been able to ascertain the borehole has been filled with rubbish by a previous occupier who manufactured glass."

5.—*Messrs. Isaac Nash & Sons, Ltd., Wollaston Mills*

Made in 1917 by Messrs. H. Brown & Co., Bristol. Particulars communicated by Messrs. Nash & Sons. These Mills are close to the Coalbournbrook Pumping Station of the Stourbridge and District Water Board's Waterworks.

Borehole (100 ft. 8 in. in diameter ; 103 ft. 5 in. in diameter) :

		Thickness Ft.	Depth Ft.
[Drift]	Gravel	2	2
[U.M.S. & ? P.B.]	Sandstone	201	203

Daily average quantity of water pumped.—15,000 gallons.

6.—*Messrs. Mark Palfrey & Co., Forward Works, Giles Hill, Stourbridge*

Made in 1897 by Thos. Baird, Kidderminster. Particulars communicated by Messrs. Palfrey & Co.

	Thickness Ft.	Depth Ft.
Shaft (40 ft., by 6 ft. square) : ...	40	40
Borehole (diameter 6 in.) :		
Sandstone [U. Mottled]	160	200

Rest-level.—45 ft. ex surface.

7.—Messrs. W. J. Turney & Co., Ltd., Mill Street, Stourbridge

Made in 1901 by Messrs. C. Isler & Co., Ltd.

	Thickness Ft.	Depth Ft.
Shaft (12 ft. × 7 ft. × 5 ft.) :		
[? U. Mottled Sandstone] ...	12	12
Borehole (diameter 11 in.) :		
Sandstone [U. Mottled] ...	198	210

Rest-level.—6 ft. ex surface. Daily average quantity of water pumped.—8/10,000 gallons per hour. The water-level has *risen* about 6 ft.

8.—Boring at the G.W.R. Goods Station, Stourbridge
(in Amblecote parish, Staffs.)

Made by Messrs. C. Isler & Co., Ltd. Communicated by W. Wickham King. Completed March 17th, 1915.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
Upper Mottled Sandstone	Soft bright-red sandstone ...	206	0	206	0
Pebble Beds	Sandy marlstone	2	0	208	0
	Dull-red sandstone	80	0	288	0
	Sandstone with pebbles up to 1 in. in diameter	8	0	296	0
	Sandstone, well banded ...	31	0	327	0
	Laminated red sandstone ...		2	327	2
	Red and grey coarse sandstone	38	0	365	2
	Dull-red sandstone with marl pellets	15	0	380	2
	Red sandstone	18	0	398	2
	Light red sandstone; pebbles 2 in. × 1½ in. × ⅞ in. ...	12	0	410	2
	Marl		2	410	4
	Dull-red sandstone, pebbles up to 1 in.	40	0	450	4
	Calcareous conglomerate and plenty of pebbles up to 1 in. ...	5	8	456	0
	Red sandstone and pebbles ...	53	0	509	0
	Red sandstone	16	0	525	0
	Red sandstone and marl ...		2	525	2
	Red sandstone and pebbles ...	16	10	542	0
	Conglomerate; pebbles up to 7 in. × 5 in. × 4 in.	48	0	590	0
Lower Mottled Sandstone	Soft red sandstone	255	0	845	0
Trappoid Breccia	Fine breccia	7	0	852	0
	Purple marls with plant-remains at 855 ft.	8	0	860	0
	Purple marls	4	6	864	6
	Sandstone	1	0	865	6
	Red sandstone and thin purple marls	2	6	868	0
	Red marly sandstone	4	0	872	0
	Purple marls and sandstone ...	9	0	881	0
	Thin green marly band ...		9	881	9
	Red sandstone		6	882	3
	Red sandstones containing fine breccia	1	0	883	3
	Red marly sandstone with plant-remains at 889 ft. and 894 ft.	13	0	896	3
	Fine breccia		3	896	6
	Sandy marl	1	6	898	0
	Very hard breccia; plant-remains at 899 ft.	1	6	899	6
	Hard dull slightly-red sandstone	2	6	902	0

Lining.—396 ft. of 11½-in. tubes, top 2 ft. 6 in. below surface. Water-level.—Standing, 14 ft. ex surface ; pumping, 16 ft. ex surface. Supply.—15,000 gallons per hour.

E. A. Newell Arber stated [1] :—" Mr. Wickham King has obtained some undoubted plant remains from the highest beds of the Enville Series (D^2 of the Upper Permian) from a boring [the above] near Stourbridge, in the parish of Amblecote. These he has very kindly shown the writer, but they are unfortunately indeterminable."

9.—*Boring at Glebe Lane, Gigmill* (see p. 146)

Stourport.—Maps : 182 ; 55 N.E. ; 14 N.W., S.W.

This Urban District is mainly on the Upper Mottled Sandstone ; but a part of the north-western portion is on the Pebble Beds. Locally, gravel occurs on the surface of these formations.

Stourport is supplied with water in bulk, now from the Bewdley Borough Council's Waterworks, but before 1913 from the Kidderminster Town Council's Waterworks ; the change was made for motives of economy. Of the 1,258 houses in the District 1,047 have the water laid on, while six are served by a standpost ; the others obtain their water from wells, chiefly because they are too far from the water mains. Two Works obtain their water from wells, namely :—

1.—*Thos. Bond Worth & Sons, Ltd., Severn Valley Mills*

Particulars communicated by the firm.

	Thickness Ft.	Depth Ft.
Well (diameter—4 ft. to a depth of 4 ft. ; then 8 ft. from 4 to 24 ft. ; widening from 8 ft. at 24 ft. to 11 ft. at 32 ft.) :—		
Upper Mottled Sandstone ...	32	32
Bore (diameter—6 in.) :—		
Upper Mottled Sandstone ...	302	334

There is an overflow pipe, 4 in. diameter, at 4 ft. from the surface. The rise and fall of the Severn has no effect on the water-level. Analysis, No. 517.

2.—*Anglo-Enamelware Ltd., Mitton Street*

Particulars communicated by the firm.

	Thickness Ft.	Depth Ft.
Well (8 ft. square) :—		
Upper Mottled Sandstone	22	22

" There is an overflow about 6 ft. below the surface and the water is usually trickling away through this. At the present time [July 24th, 1923], owing to the abnormally dry season, the water-level is about 6 ins. below the overflow ; but as a rule the water is well above the level of the Severn."

Worcester.—Maps : 199 ; 55 S.E., 54 S.W. ; 28 S.E., 33 N.E., S.E.

Worcester extends over red Keuper Marl, sand and gravel, and Alluvium. The thickness of the Marl beneath Worcester has not been ascertained : at Red Hill, Upton-on-Severn, it is 1,327 ft. thick, and at the Gas Works, Malvern Link, 703 ft.; but beneath Worcester its thickness is probably less.

The Marls had a valley excavated in them by the Severn ; sand and gravel was deposited in this valley ; then the Severn cut lower and deposited the Alluvium which forms the level ground adjacent to it and on part of which is Pitchcroft.

Water from wells in the sand and gravel on which part of the City is situate would contain high nitrates, while such water as might be encountered in the Keuper Marl would be hard.

[1] *Trans. Inst. Min. Eng.*, vol. 52, 1916–17, p. 39.

In the neighbourhood of the Worcester Brewery (Messrs. Spreckley Bros.) the sand and gravel is about 20 ft. thick ; under New Bank Street, Barlbourne, about 15 ft. 6 in. ; and it is well exposed in pits at Henwick.

Worcester is now supplied with filtered Severn water from the Corporation's Waterworks, and R. Taylor, the Chief Sanitary Inspector, informs me :— " As far as I know there are not more than 12 to 15 houses in the City which have not got the City water laid on. They are situated at Bilford Lane and Checketts Lane, on the northern boundary. I know of three Breweries in the City which obtain their water from wells."

Originally Worcester was dependent on wells, streamlets, and the River Severn.[1] The streamlets now flow in culverts and have been lost sight of.

The first piped supply was for the Monastery. The water was derived from the Prior's park at Battenhall and conveyed in pipes of wood and lead. This supply being inadequate " another was thought of from a spring above Hardwick Court, St. John's, in the grounds near St. John's green, called ' Swanpool,' " but, " ultimately a more plentiful supply was obtained from a spring at Henwick Hill, which was continued till the time of the civil wars, when the pipes were torn up, probably to cast bullets." [2]

The ' Swanpool ' referred to is now a withy-bed. ' Hardwich Spring ' is not known locally, but Hardwick's Spring Cottages, near the ' Swanpool,' probably mark its approximate position. Alongside Holywell Hill, with an inclined heavy slate roof, is Holy Well—probably the source of supply referred to above as " a spring at Henwick Hill." The water comes out of a sand and gravel bed resting on Keuper Marl.[3]

John Noake has stated [4] :—" In the 17th century the waterworks which supplied the city were erected on a small island then existing in the river near the present bridge. In 1689 the Corporation granted a lease of these works to John Hadley of West Bromwich, confirming on him the necessary powers for breaking up the streets to lay pipes and to erect over the Cross or Market Place, called the Grass Cross, a cistern of the capacity of 200 hogsheads of water, in order to the inhabitants being supplied with Severn water. . . ."

Worcester Waterworks[5]

These Works, established about 1857, supply Worcester C.B., parts of the parishes of North Claines (Droitwich R.D.), Worcester St. John's Bedwardine County (Martley R. D.), and Kempsey (Upton-on-Severn R.D.), and furnish a supply in bulk to Pershore R.D. for the villages of Spetchley and Whittington ; they also supply Norton Barracks in Norton-juxta-Kempsey (Pershore R.D.).

Powers.—City of Worcester Water, etc. Act, 1823. Limits.—Worcester C.B.

Sources of Supply.—River Severn, intake, Barbourne, Worcester.

Works.—Filtration from 180 gallons per sq. yd. per day to 230 gallons per sq. yd. per day.[6] Service reservoirs.—High Level, Elbury Hill (about 323 ft., O.D.); (a) 250,000 gallons, (b) 1,000,000 gallons : Low Level, Rainbow Hill (about 200 ft., O.D.) ; (a) 812,000 gallons, (b) 1,000,000 gallons. Pressure is sufficient.

Quantity supplied.—The daily average is 1,790,000 gallons, and 5,000 gallons in bulk. Supply is constant.[7]

Boring at New Bank Street, Barbourne

Made by Messrs. LeGrand, Sutcliff & Gell, Ltd., Southall, for Messrs. Allen Robert Mumford & Co. in 1903 on the Brewery premises. Particulars communicated by borers.

[1] For a detailed history of the water supply of Worcester see B. Brotherton, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), pp. 159–165.

[2] Noake, John, ' The Monastery and Cathedral of Worcester,' 1866, pp. 113–14.

[3] See L. Richardson, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), p. 149.

[4] ' Worcestershire Relics,' 1877, p. 116.

[5] For the history of these waterworks see Thomas Caink, *Trans. Worcs. Nat. Club*, vol. viii, pt. 3 for 1925 (1927), pp. 165–170.

[6] The filtering area is very extensive and is being added to.

[7] The quality of the Severn water has been discused by C. C. Duncan in *Trans. Worcs. Nat. Club*, vol. v, pp. 193–198, and analyses by him are given on pp. 176, 204, of the present memoir. See also ' The Investigation of Rivers—Final Report,' *Royal Geographical Society*, 1916, pp. 83–88 ; and p. 5 of present memoir.

		Thickness Ft.	In.	Depth Ft.	In.
Superficial Deposits	Top soil...	3	0	3	0
	Gravel and sand	3	6	6	6
	Sand	10	6	17	0
	Sand and gravel	1	6	18	6
Keuper Marl	Red and blue marl	79	6	98	0
	Red marl and gypsum ...	16	0	114	0

Depth below surface of water-level.—20 ft. Yield.—1,000 gallons per hour. Lowers water 42 ft. Tubing remaining in borehole :
20 ft. of 10-in., 8 ft. 6 in. below surface
45 ft. of 8½-in., 7 ft. „ „

Boring at Lewis Clark & Co. (Angel Place)

Made and particulars communicated (1901) by Messrs. C. Isler & Co., Ltd.

		Thickness Ft.	Depth Ft.
Keuper Marl	1. Red marl	69	69
	2. Red marl rock	26	95
	3. Red marl rock and white spar [gypsum]	9	104
	4. Red marl rock	58	162
	5. Blue and red marl	3	165

IV.—CHIEF REGIONAL WATER UNDERTAKINGS

East Worcestershire Waterworks Company [1]

Supply Bromsgrove U.D. (whole); North Bromsgrove U.D. (part); Redditch U.D. (part); and parts of the parishes of Ipsley (Alcester R.D.); Alvechurch, Bentley Pauncefoot, Grafton Manor, North Redditch, Stoke Prior, Tutnall and Cobley, and Webheath (Bromsgrove R.D.); Dodderhill, Hadzor, and Upton Warren (Droitwich R.D.); and furnishes supply in bulk to Droitwich T.C.; Studley (Alcester R.D.); Bromsgrove R.D.C. (part of); Feckenham U.D.C. and R.D.C. The limits include, in addition to the above, Sambourn (Alcester R.D.); Doverdale, Elmbridge, Elmley Lovett, Hampton Lovett, Hanbury, Ombersley, Westwood Park (Droitwich R.D.); Chaddesley Corbett and Rushock (Kidderminster R.D.).

Powers.—East Worcestershire Water Acts, 1877 and 1902.

Sources of Supply.—As follows:—

	Burcot [2]			Catshill [3]	
	No. 1	No. 2	No. 3	No. 1	No. 2
Surface-level (O.D.)	427	427	424	374	374
Depth of shaft (ft.)	100	—	—	10	—
Depth of borehole (ft.) ...	200	402	800	297	300 [3]
Diameter of shaft (ft.) ...	10	—	—	—	—
Diameter of borehole (in.) ...	20	20	20	20	20
Depth to water-level (ft.) ...	93	93	93	5	5
Yield per hour (gallons) ...	54,166 (estimated)			25,000	5,000
Daily average pumped in half-year ending Dec. 31st, 1922 (gallons)	1,033,913			186,091	

Works.—No filtration. Pressure sufficient.

Service reservoirs:—	Ht. above O.D.	Capacity in gallons
Burcot (close to Pumping Station)	427 ft.	300,000
Lickey Hills (near Monument)	900 ft.	50,000
Headless Cross (Redditch U.D.)	541 ft.	200,000
,, ,, Tower (Ditto)	541 ft.	20,000
Whetty Bridge (N. Bromsgrove U.D.) ...	741 ft.	500,000

Pumping Stations:— Burcot; Washingstocks, Catshill.

Quantity of water supplied.—The daily average is 1,010,572 gallons and 145,558 gallons in bulk. Supply is constant.

Quality of water.—Analyses, see p. 190.

Particulars of Strata in Boreholes at Burcot

No. 1.—*Original well and borehole at Pumping Station.*

Information obtained by C. E. de Rance from W. T. Layton, C. E., and published in *Rep. Brit. Assoc.*, 1889, pp. 72, 73.

" Well and borehole constructed in 1881.

" Well 100 ft.; borehole, 200 ft.; total, 300 ft.

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[1] The Company's Office is at Bromsgrove.

[2] In North Bromsgrove U.D.

[3] Pump direct from borehole.

" When pumping is suspended for 6 hours the water rises and overflows the surface.

" Could obtain 2¼ million gallons. Yield at present, pumped down to 70 ft. from the surface, 516,000 gallons per day.

" [Yield] Does not vary.

" No section preserved. It [boring] commences in the Upper Bunter and probably terminates in the Pebble Bed or Middle Bunter."

W. J. Shinner, late Manager, informs me that the overflow ceased when hard pumping began 40 years ago and that, the yield on test having been found in 1891 to have fallen to 432,000 gallons per day ; new boreholes were made in consequence.

No. 2.—*Near the 'Original Well.'*

Particulars communicated by W. J. Shinner.

	Thickness Ft.	Depth Ft.		Thickness Ft.	Depth Ft.
Soil	3	3	Medium sandstone ...	14	252
Sand and sandstone ...	6	9	Coarse sandstone ...	14	266
Sandstone and marl ...	24	33	Marl and sandstone ...	2	268
Fine sandstone and marl	1	34	Sandstone and marl ...	22	290
Fine sandstone ...	5	39	Open sandstone ...	18	308
Marl and sandstone ...	21	60	Marl and sandstone ...	2	310
Hard sandstone ...	42	102	Open sandstone ...	17	327
Softer sandstone ...	10	112	Coarse sandstone ...	21	348
Loamy marl	2	114	Sandstone and small pebbles	2	350
Hard sandstone ...	11	125	Coarse sandstone ...	12	362
Hard marl	4	129	Loamy marl	7	369
Loamy sandstone ...	20	149	Loamy sandstone ...	4	373
Fine hard sandstone ...	50	199	Fine, very hard sandstone	20	393
Loamy sandstone ...	1	200	Coarse sandstone ...	9	402
Open sandstone ...	2	202			
Sandstone	36	238			

[Upper Mottled Sandstone 3 to 238 ft., Pebble Beds 238 to 402 ft.]

No. 3.—*At north corner of field in which the Pumping Station is situate.*

Made in 1910 and particulars communicated by W. J. Shinner.

	Thickness Ft.	Depth Ft.
Soil and sand	4	4
Soft sandstone	21	25
Sandstone	29	54
Loamy sandstone	16	70
Sandstone	2	72
Fine sandstone	6	78
Fine soft sandstone	2	80
Dense red marl	3	83
Soft sandstone	6	89
Loamy sandstone	21	110
Hard sandstone	12	122
Loamy sandstone	4	126
Hard sandstone	60	186
Loamy sandstone	6	192
Very hard sandstone	6	198
Sandstone and red marl	7	205
Sandstone	2	207
Open sandstone	13	220
Loam and soft sandstone	4	224

	Thickness Ft.	Depth Ft.
Sandstone	2	226
Hard sandstone	40	266
Soft sandstone and pebbles	16	282
Marl and a little sand	4	286
Soft sandstone	1	287
Sandstone	3	290
Sandstone and pebbles	28	318
Sandstone and marl	1	319
Open sandstone	1	320
Hard sandstone	5	325
Softer sandstone...	12	337
Soft sandstone	3	340
Medium sandstone	16	356
Very open sandstone	34	390
Coarse sandstone	4	394
Medium sandstone	6	400
Soft yellow sandstone	13	413
Soft yellow sandstone, darker	16	429
Coarse sand and pebbles up to ½ in. in diameter ...	3	432
Red marl	1	433
Hard fine-grained sandstone	20	453
Very hard and coarse sandstone with pebbles up to 1 in. in diameter and mica flakes	1	454
Hard pale-red sandstone with occasional small pebbles. Softer than preceding bed	21	475
Course, soft dark sandstone	4	479
Similar rock, but with many pebbles up to ½ in. in diameter	2	481
Similar rock, but with fewer pebbles	1	482
Darker sandstone, streaky, with a few pebbles, but not so coarse as above	10	492
Loamy sandstone, no pebbles	4	496
Medium-grained sandstone	3	499
Coarser sandstone ; pebbles up to 1 in. in diameter...	7	506
Softer sandstone dusted with felspar and mica ...	12	518
Coarse sandstone ; few small pebbles	6	524
Coarse grit ; few small pebbles	2	526
Coarse grit and sandstone	9	535
Soft dark sandstone	42½	577½
Finer sandstone	1	578½
Rough grit and pebbles...	6	584½
Soft yellow sandstone	3	587½
Rust-coloured grit, pebbles up to 10 in. in diameter	8½	596
Rust-coloured sandstone, small and large pebbles ...	14½	610½
Very coarse grit and small broken pebbles	1	611½
Coarse chocolate-coloured sand and pebbles up to 8 in. in diameter and soft brown pebbles ...	11½	623
Red sand with soft round and angular pebbles up to 16 lbs. in weight. Permian Breccia	28½	651½

		Thickness Ft.	Depth Ft.
Same as preceding item, with darker sand and pebbles in following proportions per cent. :—			
Granular marly sand	45		
Soft round pebbles over ½ in. in diam. ...	10		
,, ,, ,, under ½ in. ,, ,, ...	6		
,, angular ,, over 2 in. ,, ,, ...	25		
,, ,, ,, between ½ & 2 in. in diam.	4		
,, ,, ,, under ½ in. in diam. ...	10		
	100	128½	780
[Sand and pebbles in the following proportions per cent. :—]			
Granular sand merging into small pebbles	75		
round soft pebbles up to ⅜ in.	5		
angular pebbles up to 1 in. ...	20		
	100	20	800

[Upper Mottled Sandstone 4 to 226 ft. ; Pebble Beds 226 to 623 ft. ; Trappoid Breccia 623 ft. to bottom.]

Wickham King informs me that he saw the cores from 623 to 800 ft., and that the dip was clearly 35°.

PARTICULARS OF STRATA IN BOREHOLES AT WASHINGSTOCKS, CATSHILL

No. 1.—*Near stream about 180 yds. E.N.E. of the Pumping Station.*

Made (1899) and particulars communicated by Messrs. C. Isler & Co., Ltd.

	Thickness Ft.	Depth Ft.
Dug Well :—		
[? Soil and sand] ...	10	10
Borehole :—		
Running sand and large boulders ...	1	11
Sandstone, gravel and marl	16	27
Marl and sand ...	11	38
Sandstone with traces of gravel and marl	37	75
Conglomerate ...	17	92
Sandstone	46	138
Running sand ...	3	141
Sandstone with layers of red marl ...	37	178
Red marl	2	180
Sandstone	127	307

[Lower Keuper Sandstone 10 to 92 ft. ; Upper Mottled Sandstone 92 to ? 262 ft. ; Pebble Beds ? 262 ft. to bottom].

Lined with 6 ft. of 23-in. tubes, top 10 ft. below surface
,, ,, 50 ft. ,, 20-in. ,, ,, 3 ft. ,, ,,
Water overflows bore-pipe [but not now].

No. 2.—*At Pumping Station.*

Made (1900) and particulars communicated by Messrs. C. Isler & Co., Ltd.

	Thickness Ft.	Depth Ft.
Sandstone	20	20
Sandstone and marl	7	27
Conglomerate	3	30
Sandstone	24	54
Sandstone and marl	3	57
Sandstone	5	62
Sandstone and marl	4	66
Marl	5	71
Sandstone and marl	4	75

	Thickness Ft.	Depth Ft.
Sandstone	21	96
Sandstone and marl	2	98
Marl	2	100
Sandstone	34	134
Sandstone and marl	6	140
Marl	7	147
Sandstone	43	190
Conglomerate	2½	192½
Sand	1	193½
Sandstone	3½	197
Sandstone and marl	3	200
Sandstone	66	266
Conglomerate	9	275
Hard sandstone	0½	275½
Conglomerate	1½	277
Sandstone	9	286
Conglomerate	2	288
Sandstone	10½	298½
Conglomerate	1½	300

[Lower Keuper Sandstone to 30 ft. ; Upper Mottled Sandstone 30 to ? 200 ft. ; Pebble Beds ? 200 ft. to bottom].

Lined with 9 ft. of 24-in. tubes, top 6 ft. 6 in. below surface
,, ,, 86 ft. ,, 20-in. ,, ,, 5 ft. ,, ,,
Water-level [at completion of boring] 2 ft. 7 in. ex surface.

Evesham and Pebworth Joint Water Committee

This scheme was approved and carried out in 1895, the original works being at Broadway and Buckland ; but in 1913 considerable augmentation of supply was effected by the purchase of six springs (yielding 250,000 gallons per day) in Lidcombe Wood on a 99 years' lease from Lord Elcho for £9,000, and the works were completed in 1914.

Supplies.—Aston Somerville, Cow Honeybourne, Hinton-on-the-Green, Pebworth (Pebworth R.D.C.), Long Marston (Marston Sicca R.D.C.)—Glos. ; Aldington, Badsey, Bretforton, Church Honeybourne, Cleeve Prior, Great and Little Hampton, Harvington, North and South Littleton, Offenham, Sedgeberrow and Wickhamford—Worcs.

Sources of Supply.—Springs from the Cotteswold Sands and Inferior Oolite, thrown out by the Upper Lias clay, at Broadway, Worcs., Buckland, Glos., and in Lidcombe Wood, Stanway, Glos. The actual appearance of the water is often at a somewhat lower level than the outcrop, owing to slipped Oolite. R. J. Atkinson, Surveyor to the Evesham and Pebworth R.D.Cs. informs me that the quantity from all three sources is at least 400,000 gallons per day.

Works.—Service reservoirs : Broadway, 51,000 gallons ; Baylis Hill, Pebworth, 20,000 ; Littleton, 15,000 gallons. The springs in Lidcombe Wood are tapped by headings driven into the hill and brought to two small collecting chambers. No storage is necessary. From the chambers the water is conveyed to the villages in cast-iron mains. At Buckland there is only a collecting chamber. The supply to the reservoirs from the mains is a constant one. There is no filtration.

Quantity.—The average daily quantity of water supplied is 120,000 gallons, and the supply is constant and more than sufficient.

Quality.—Excellent for drinking purposes being perfectly pure and free from any sort of contamination (Analyses Nos. 229–236). No plumbo-solvent action. Periodical samples are taken to test freedom from any contamination.

South Staffordshire Waterworks Company [1]

(So far as concerns Worcestershire)

Supplies Dudley C.B. ; Oldbury U.D. ; parishes of Cakemore, Hill, Hawne, Halesowen, Hasbury, Cradley, Lutley (Halesowen R.D.) ; Hunnington and Romsley (Bromsgrove R.D.).

Limits.—The above and, in addition, Illey and Lapal (Halesowen R.D.).

Powers.—South Staffordshire Waterworks Acts, 1853, 1866, 1875, 1878, 1893, 1909, 1913, 1915 and 1922 ; S. Staffs. Waterworks Amendment Acts, 1857 and 1864 ; S. Staffs. Waterworks Order, 1901 ; Dudley Waterworks Act, 1834, Dudley Waterworks Amendment Act, 1853 ; Burton-on-Trent Waterworks Act, 1861.

Sources of Supply.—None in Worcestershire.

Works.—

Service reservoirs :—

	Capacity in gallons
Spring's Mill, Dudley	3,250,000
Cawney Hill, Dudley	1,000,000
Ditto. Tank	100,000
Bristnallhall Road, Warley	1,000,000
Romsley	20,000

Re-pumping Stations :—

Spring's Mill and Cawney Hill, Dudley.

Quantity of Water supplied (in Worcestershire) :—Estimated daily average, about 2,750,000 gallons.

Stourbridge and District Water Board

The districts supplied are Stourbridge Borough ; Amblecote U.D. (part) ; Lye and Wollescote U.D. (part) ; and Wordsley (Kingswinford R.D.). The authorities for these districts are all constituent and are represented on the Board. Portions of Bromsgrove R.D., i.e. Hagley, Pedmore and Clent, are included in the Board's Parliamentary area, but are not constituent. Bulk supplies are given to the Kidderminster R.D.C. in two places : this Council is beyond the Board's area.

Powers.—Stourbridge and District Water Board Act, 1909 (by which the Board took over on January 1st, 1910, the Stourbridge Water works Co.) ; Stourbridge and District Water Board Order, 1923.

Limits.—See first paragraph.

Sources of supply (for further details see below) :—

	Coalbourn-brook	Mill Meadow	Tack
Surface-level (ft., O.D.)	217.7	228.9	225.2
Depth of shaft (ft.)	44	50, but now filled in	20
Depth of borehole below shaft (ft.)	457	201.7	190
Depth to water-level (ft.), standing	16, after 2 or 3 hrs.	Overflow at 220 ft. O.D.	28
Average daily quantity (gallons)	1,200,000	350,000 [2]	500,000

Wm. B. Cleverly, Engineer and Manager to the Board, informs me that now "all the pumping is done at Coalbournbrook ; Millmeadow Standby Engine for High Level ; Tack Standby Works for Low Level. There is also a 20-inch borehole at Glebe Lane, Gigmill, which has never been used, and it is extremely unlikely that it ever will be."

[1] The Company's head office is in Paradise Street, Birmingham. I am indebted to Mr. Fred. J. Dixon, Engineer-in-Chief, for the information given above.

[2] 1,000,000 when required ; originally 500,000 regularly.'

Works.—No filtration.

Service reservoirs :—

Wychbury Hill, Pedmore. Altitude above O.D., 560 ft. Capacity, 87,000 gallons. Old portion not in use ; new reservoir for 300,000 gallons to be built.

Doctor's Hill, Stourbridge. Altitude above O.D., 420 ft. Capacity, 500,000 gallons.

The service reservoirs at Amblecote Lane (380,000 gallons), and Careless Green, Wollescote (20,000 gallons), have been abandoned.

Quantity supplied.—The daily average is 1,240,000 gallons. Supply is constant. Quality.—Analyses Nos. 507–515.

Particulars of Strata in Boreholes

1.—*Coalbournbrook, Amblecote, Staffs.*

Particulars communicated by W. Wickham King. To 197 ft. 6 in. from notes by J. T. Short : from 197 ft. 6 in. to 501 ft. from notes—checked with core by Mr. King—by man who continued the borehole in 1911.

	Thickness Ft.	Depth Ft.
Shaft :—		
Surface soil	}	
Sandstone	} 42½	42½
Marl	1½	44
Borehole (diameter, 20 in.) :—		
Sandstone	8	52
Sandstone, harder	5½	57½
Sandstone	7½	65
Hard sandstone	6¾	71¾
Marl	5½	77¼
Hard sandstone	1¾	79
Hard sandstone	18½	97½
Very hard sand grit	7	104½
Softer sandstone...	6½	111
Marl	1½	112½
Hard sandstone	4	116½
Softer sandstone...	13	129½
Grey-streaked sandstone	0½	130
Sandstone	9½	139½
Marl	1	140½
Fine clean very hard sandstone	4½	145
Fine open quite dry sandstone	16½	161½
Sandstone comes up very clean	7	168½
Very hard sandstone	2	170½
Less hard sandstone	5	175½
Marl and sandstone	2	177½
Hard sandstone	}	
Sandstone which coloured the water	} 6	184
Clean very sharp sand	6	190
Hard sandstone	3	193½
Sandstone	4	197½
Dull red sandstone with a few pebbles ½ in. and under	16½	214
Red marl	¾	214¾
Dull red sandstone with a few pebbles ½ in. and under	23¼	238
Sandstone and several thin bands of marl	2	240
Fine light red sandstone	3	243
Dark red sandstone	8	251
Dark red sandstone with pebbles up to 1 in.	37	288
Dull red gritty sandstone	5	293
Dull red gritty sandstone with pebbles up to ½ in. (rare)	8	301

	Thickness Ft.	Depth Ft.
Dull red sandstone	6	307
Sandstone with many pebbles up to ½ in.	2½	309½
Bright red sandstone, few pebbles	5½	315
Conglomerate, pebbles up to 1 in.	0½	315½
Dull red gritty sandstone	5½	321
Bright red sandstone and layers of marl ½ to 2 in. thick	5	326
Marl	2	328
Bright red sandstone with several layers of marl ½ to 2 in. thick	6	334
Fine dull red sandstone, no pebbles	8	342
Bright red sandstone with layers of red marl ½ to 4 in. thick	10	352
Micaceous dull red gritty sandstone and a 6-in. band which was greenish-white	13½	365½
Red marl	2	367½
Sandstone ; no pebbles. Dip 20°	15½	383
Fine calcareous conglomeratic sandstone	7	390
Massive conglomerate, pebbles up to 1 in.	5	395
Coarse conglomerate, pebbles loose and up to 4½ in. in diameter	14½	409½
Homogeneous bright red sandstones, with (in first 30 ft.) six bands (in thickness—6, 4, 5, 3, 3, and 6 in.) of greenish-white sandstone. Devoid of pebbles...	91½	501

Upper Mottled Sandstone to 97½ ft. ; Pebble Beds 97½ to 409½ ft. ; Lower Mottled Sandstone 409½ ft. to bottom.

The following reply to a schedule of questions by E. B. Marten, Engineer to the late Stourbridge Waterworks Company, was published in 1882 [1] :—

" 1. [Position of well or shafts] Wollaston [i.e. Coalbournbrook] Station of the Stourbridge Waterworks at Coalbournbrooke, between Wordsley and Stourbridge, on the road to Wollaston Hall, and between Canal and River Stour, just under the *Platts* on Ordnance Survey [map]. 1*a*. [Sunk] 1880, July 44 ft. deep, and bore-hole 179 ft. ; May 1882 sunk 20 ft. deeper., 2. [Surface level] 218 ft. above sea-level. 3. Well 44 ft. from surface ; bottom of bore-hole 179 ft. from surface. 3*a*. No driftways [from well]. 4. Water rises to the surface, and flows into River Stour. If pumped empty well fills in 25 minutes. If pumped down 4 ft. it rises and overflows in 3 minutes. A pipe fixed in bore-hole can be shot off from the well, and the water rises 10 or 12 ft. above the surface in good volume, but it has not been tested as to what height of pipe would prevent overflow. 4*a*. The first 10 ft. only were dry, and then the water increased very fast. 5. [Yield] 600,000 when pumped about 20 ft. below surface ; average 300,000 gallons per day at about 4 ft. below surface. 6. No variation [in water-level] can be observed, and no diminution. 7. Rain makes no difference [to water-level] ; ordinary level stands about 10 ft. above River Stour, which is about 100 yds. away. 8. [Analysis] Practically the same as at Mill Meadow. The waterworks were originally set out here, but moved nearer the town to a well still used, and which has served for 20 years. 9. [Section] This drift then all Upper Mottled Sandstone. 9*a*. Red sandstone rock is of uniform texture a little more at about 43 ft. from surface. 10. No surface spring in drift, but if holes are made they fill with water. 11. Land springs are coffered out. 12. No faults are seen near the well. 13. No brine [encountered in the sinkings]. 14. No [salt springs in neighbourhood]. 15. No [wells in neighbourhood stopped because of brine]. 16. [Any other information]

[1] *Rep. Brit. Assoc.*, 1882, pp. 219–220.

The New Red Sandstone occupies a large area from the western boundary fault of the South Staffordshire coalfield to Enville, and forms the gathering ground for the well. It has few large streams on it, as it is so permeable that the rainfall percolates easily. There are no large towns on this area, but villages and gentlemen's country seats, including Enville Hall, Lord Stamford's, and the famous Sheep Walks. The rock is full of water, which overflows along the banks of the river, and the long overflow has formed springs or wells in the sandstone escarpment, one of which is called the 'bottomless pit,' from the persistency of the outflow of the water in great volumes at all seasons uniformly. This company purchased the right to run a heading at 50 ft. below the surface from the Wollaston well under this escarpment to another site at Tack Farm, half a mile away, but the borehole has yielded all that is needed without any chance of river water getting into the well. The Wollaston site was that originally chosen for the works, but it was considered that the same condition would appertain at Mill Meadow, the site near the town, although no site of a spring was then seen. It was found exactly as conjectured, and answered for the town supply for 20 years, and being between the town and reservoir a much less outlay was sufficient."

2.—*Millmeadow, Amblecote, Staffs.*

The following particulars are taken from an old record lent me by Mr. Cleverly. The borehole, 201 ft. 7 in. deep and 20 in. diameter, is now the sole source of supply at this Pumping Station : the smaller holes and wells have been filled up.

Surface-level.—228.9 ft. above O.D.

		Thickness Ft.	In.	Depth Ft.	In.
	Borehole (diameter, 20 in.) :				
[Upper Mottled Sandstone]	Sandstone	79	6	79	6
[Pebble Beds]	Sandstone very hard	2	0	81	6
	Sandstone with some small pebbles at 85 ft.	17	6	99	0
	Sandstone (Water-level 20 ft. 4 in. ex surface here) ...				
	Running sand	100	1	199	1
	Sandstone				
	Sandstone with a little marl at 117 ft.				
	Sandstone with layers of marl at 129 ft.				
	Sandstone				
	Sandstone very hard at 150 ft.				
	Sandstone darker at 160 ft. ...				
	Sandstone and marl (Water-level 15 ft. 6 in. ex surface)...				
	Sandstone and marl				
	Sandstone and marl (Water-level 15 ft. 6 in. ex surface)				

[Given as 201ft. 7in. in original.]

Rest-level.—14 ft. 6 in. ex surface or 214.3 ft. above O.D.

The wells here—according to the record—were 40 ft. deep. In the headings and wells were three boreholes :—

One 7 in. diameter and 120 ft. deep.
,, 7 in. ,, ,, 140 ft. ,,
,, 10 in. ,, ,, 200 ft. ,,

Pumping commenced in 1857 and the average quantity pumped daily was 500,000 gallons.

E. B. Marten furnished the following particulars concerning the Millmeadow Works[1]:—" 1. [Site] At the Mill Meadow Pumping Station, near Stourbridge, ¼ mile N.E. of centre of town. 1*a*. Sunk in 1856 to depth of 50 ft., with a borehole 20 ft. from the bottom of the well. In 1871 it was deepened to 50 ft., with a borehole 80 ft. deeper and drift-ways made ; two other shafts were also sunk for convenience. 2. Surface of the ground or engine-house floor 237 ft. above the sea (O.D.). 3. 50 ft. to the bottom of the well. 130 ft. to bottom of borehole. 3*a*. [Depth from surface to drift-ways] 44 ft. Length about 40 yds. 4. Water would rise to the surface and flow into the River Stour, but a drain-pipe is put into the river about 10 ft. from the surface. When pumping 300,000 gallons per day it sinks 20 ft. and fills again in two hours. When pumping 550,000 gallons 30 ft., and recovers in four hours. 4*a*. The water rose to surface and flowed over [when the well was first sunk], and would do so again. 5. [Yield] About 600,000 gallons per 24 hours. No difference [in water level] in seasons. After 15 years it was tested and found to yield exactly the same quantity. 7. Local rain does not affect it [i.e., the ordinary water-level]. It stands 10 ft. above the River Stour. 8. [Analysis, No. 658] This site was chosen as it was conjectured that the rock was as overflowing as the more distant site at Wollaston originally chosen. This has been suffused in 20 years, and being between the town and the high-level reservoirs it saved much outlay. The gathering ground for this well is supposed to be the Clent Hills, and the large sandstone area of Hagley and Clent Heath. 9. [Section] No drift. Well was commenced in the rock. 9*a*. Water comes chiefly out of the boreholes. 10. No springs, but if any hole was made it would fill with water. 11. As the well is generally full land-springs cannot come in. New pumping stations are purchased to prevent the need of drawing down this water permanently. 12. The Western boundary fault of the [South] [Staffordshire] coalfield [is situate] 200 yards to east. 13. No brine springs [encountered when sinking]. 14. None near [i.e., brine springs]. 15. No wells [near] stopped because of brine. 16. [Further information] Two wells [the G.W.R. wells] near."

3.—*Tack, Wordsley, Kingswinford, Staffs.*

Particulars communicated by W. Wickham King and taken by him from specimens kept at the Stourbridge and District Water Board's office.

		Thickness Ft.	Depth Ft.
	Well :—		
Superficial Deposits.	1. [Drift (see below)]	10	10
Pebble Beds	2. Micaceous dull red sandstone ...	10	20
	Borehole (diameter, 20 in.) :—		
	3. Micaceous dull red sandstone ...	3	23
	4. Conglomerate	20½	43½
	5. Dull red sandstone	3	46½
	6. Conglomerate	13½	60
Lower Mottled Sandstone	7. Sandstone	150	210

Mr. Cleverly informs me that " As far as I can ascertain the greater part of the first ten feet of Tack dug well was drift : if not all."

[1] *Rep. Brit. Assoc.*, 1882, pp. 220, 221.

Boring at Glebe Lane, Gigmill, Stourbridge

Made by Messrs. H. Brown and Co., Bristol, for the late Stourbridge Waterworks Co. Commenced 18th Feb., 1897 ; finished 8th May, 1898.

(a) Particulars communicated by Messrs. Brown and Co.

	Thickness Ft.	Depth Ft.
Borehole (diameter, 20 in.) :—		
Subsoil	10	10
Sandstone	21	31
Pebbles	1	32
Sandstone	58	90
Sandstone	2½	92½
Marl	0½	93
Sandstone and marl in thin layers ...	20	113
Marl	76	189
Sandstone	79½	269½
Marl	10¼	279¾
Sandstone	45¼	325
Marl and mica ...	1	326
Sandstone	46	372
Pebble Bed	28	400

[Pool mud and ? Drift to 32 ft. ; remainder, Bunter].

Water-level (standing).—33.5 ft. ex surface. Yield.—On 9th May, 1908, a test gave 500,000 gallons per day ; but the water-level fell to 81.5 ft. ex surface.

This borehole has never been used (p. 141). It is temporarily covered over and is now the property of the Stourbridge and District Water Board.

(b) An account from W. Wickham King. He says : " I had the record from Mr. Job Short who was Mr. E. B. Marten's assistant, when he was Engineer to the Stourbridge Waterworks. The boring was done by pounding (no cores were drawn) and I did not see the material. Below 392½ ft. the beds may be Keele [Upper Coal Measures]."

	Thickness Ft.	Depth Ft.
Pool mud	7	7
Running sand ...	2	9
Loose gravel ...	1	10
Red sandstone ...	21	31
Pebble Bed ...	1	32
Red sandstone ...	60½	92½
Marl	0½	93
Sandstone and a little marl	20	113
Sandstone with bands of marl	2	115
Marl chiefly ...	74	189
Sandstone	31	220
Sandstone, not so hard	24	244
Sandstone, lighter colour	18	262
Marl	1	263
Sandstone	5	268
Marl	8½	276½
Sandstone	48½	325
Dark micaceous marl	1	326
Sandstone and at the base sandstone mixed with marl	16	342
Sandstone, coarser at 362 ft. ...	30	372
Sandstone and small pebbles	20¼	392¼
Hard rock—broke chisel ...	6¾	399
Marl	1½	400½

(? Drift, 7 to 32 ft. ; Bunter, 32 to 401 ft. ; ? Keele Beds, 392½ ft. to bottom)

V.—ANALYSES OF WATERS

Introduction

By Cecil Cooke Duncan, F.I.C., F.C.S., County Analyst

Of the analyses given in the following pages, the great majority (Tables I and II, pp. 151 to 177) are a selection from some eight thousand made by the County Analyst in the County Chemical and Bacteriological Laboratories at the Shirehall, Worcester, between the years 1899 and 1924. Records of all analyses made there are kept in the Office of the County Analyst at the Shirehall, and may be referred to at any time during office hours by those requiring information about the water supplies in their area.

As far as possible, analyses of waters that proved to be good or satisfactory have been quoted, the object being to give an idea of the characters of the waters from the different geological formations, and also from the point of view of Public Health.

Contamination of well waters.—Many well waters were found on examination to be contaminated although drawn from a geological formation containing water of good quality. The contamination in many cases was due to the fact that the wells were close to inhabited houses where the soil within the collection area of the well was contaminated by slop water, house refuse, sewage (on account of defective drains, etc.), and manures. In many cases there has been great natural purification of the contaminated liquid before it entered the wells as shown by the very high nitric nitrogen content. In many of these waters the organic matter had practically disappeared and the only evidence of past contamination was the very high nitric nitrogen and chloride content. These waters must be looked upon with great suspicion because a heavy rainfall might wash some unoxidised organic matter through the soil into the well, thus rendering the water a dangerous one for human consumption.

In many cases the organic contamination can be, and has been, stopped by properly constructing the top of the well so that any rapid flow of contaminated liquid into the well is prevented. The surface water should be excluded by raising up the lip of the well to twelve inches above the surface of the ground by means of bricks. The top of the well should be surrounded by a layer of about six feet in breadth of cement, and the upper 9 to 12 feet of the well should be so lined with brick and clay puddle as to prevent any percolation of surface water into the well. By so protecting the top of a well, any contaminated liquid would have to be filtered through some twelve feet of soil before it enters the well. This will in many cases so improve the surface water as to render it fit for drinking

purposes. Large stoneware pipes form an excellent internal tubing for shallow wells. The joints should be carefully cemented and the lowest portion of the pipe—that immersed in the water—should be perforated.

If possible the well should be covered. This, however, cannot be recommended for many wells sunk in the Lower Lias, because much sulphuretted hydrogen collects in the water and well. The odour produced by this gas is always most strongly objected to by the consumers of the water. In this case the top of the well must be left open for ventilation. If the top of the well is raised a foot at least in these cases there is little chance of small animals falling in and contaminating the water. If the open well is close to trees, etc., the leaves may be kept out by covering the mouth of the well with a fine wire netting.

On several occasions well water taken from an uninhabited house was found to be quite fit for drinking purposes, but soon after the house was inhabited complaint was made that the water was becoming unpleasant. Analysis showed the water to be contaminated, and the drains on examination proved to be leaking, thus contaminating the well. It is therefore of little use to depend entirely on the analysis : the drains, etc., should be examined before the house is re-inhabited.

Again, for years a well may give good water when suddenly it becomes contaminated. This is of quite frequent occurrence on the Upper Keuper Marl and heavy clay soils—especially after a dry season. In all cases which have been investigated it was found that the soil cracked on drying. The cracks were quite large and had fractured the drain pipes.

Another frequent cause of change in the quality of the water is due to increased consumption with the result that the collecting area of the well is enlarged, and water, more or less contaminated, is drawn into the well. This occurs in dry weather especially in the more porous water-bearing beds in closely-inhabited areas.

Many good sources of supply are contaminated by carelessness. Spring-water, for example, should be collected at the source and not after it has passed along a stream because of the possibility of surface contamination. In all cases the surroundings of the spring should be protected from contamination.

Waters collected in Superficial Deposits (sand and gravel) resting on the Lower Lias vary very considerably in composition. They may at times contain much mineral matter and during dry weather wells may run dry. They frequently contain drainage of the houses erected on these deposits and often the evidence of past contamination is shown by the high nitric nitrogen and chloride content of the well waters.

Collection of samples for analysis.—The proper collection of samples of water for analysis is little understood even by those in authority. Instructions and special bottles are issued from the County Laboratory for the proper collection and marking of samples.

The analyses given are of samples taken with reasonable care. Now and again, however, a sample is received which gives figures which one would not expect from the district whence it is said to have been collected. A personal visit or a visit by the Sanitary Inspector has always been made to clear up the matter.

Many samples taken from wells which have just been sunk do not show a satisfactory composition. In such cases it is always advised that much water be pumped to waste (care being taken that the pumped water does not find its way back into the well) before the final sample is taken for analysis. In 75 per cent of such cases the final water shows a great improvement in quality when compared with the first sample.

Arrangement and Explanation of the Tables of Analyses

The analyses in this memoir are arranged in two divisions—the *Tables* (below), giving the results of analysis, and the *List* (p. 183) showing the localities from which the samples were taken, with geological formations, reference to authorities, and other information.

Every analysis is distinguished by a Reference Number, shown in clarendon type thus: **303,** both in List and in Tables.

All analyses in these tables[1] *are expressed in parts per* 100,000 (by weight),[2] with the exception of the Hardness, which is in degrees Clark.[3]

TABLES OF ANALYSES

A.—Analyses by C. C. Duncan, County Analyst.

Table I (pp. 151 to 176) contains the bulk of the analyses, Nos. 1-624, all presented in the same form. The quality of the various waters is briefly indicated, but no attempt has been made to give an elaborate report on them. An explanation of the symbols and abbreviations used in this table appears below (p. 150).

Table II (p. 177) gives the results of special determinations of the mineral constituents of certain waters, almost all of which appear also in Table I. Average figures of several analyses are given in some cases.

B.—Other Analyses.

Table III (pp. 178, 179; Nos. 629 to 652) and Table IV (pp. 180 to 182, Nos. 639 to 671) contain other analyses from various sources. To facilitate comparison, these have all been reduced to the same terms (parts per 100,000) as those of the preceding tables, and older chemical terms have been given their probable modern equivalents. Any doubts have been indicated in footnotes; the original form of analysis can in any case always be ascertained by looking up the references quoted in the List.

---

[1] With a very few clearly indicated exceptions.

[2] Parts per 100,000 are converted into grains per (imperial) gallon (parts per 70,000) by multiplying by 7 and dividing by 10.

[3] One degree Clark is the hardness equivalent to that produced by 1 grain of carbonate of lime in a gallon of water, and each degree present indicates that about 12 parts of best hard soap per 100,000 parts of the water, or 1.2 lbs. of soap per 1,000 gallons, are precipitated as curd and wasted by the water, before the soap can begin to form a proper lather and so become available for washing—unless the water is previously softened.

Explanation of the Numbers and Abbreviations used in Table I.

The *italic* numbers appearing in the left hand column of these analyses have the following meanings :—

1. Colour of Sample.
2. Deposit, description of.
3. Smell.
4. Solids in suspension, amount } in parts by weight per
5. ,, ,, solution, dried at 100°C. } 100,000
6. ,, ,, ,, , appearance on drying.
7. ,, ,, ,, , amount after ignition (in parts per 100,000).
8. ,, ,, ,, , behaviour on ignition.
9. Phosphates. } in parts by weight per 100,000.
10. Chlorine calculated as common salt
11. Ammonia, free and saline
12. ,, , albuminoid
13. Oxygen absorbed in 3 hrs.
14. Nitrogen in nitrates (nitric nitrogen)
15. Hardness, permanent } in degrees Clark (see p. 149, foot-
16. ,, , temporary } note 3)
17. Short report.

In addition to the above determinations, all the samples in Table I have been tested for *Poisonous Metals*, which in every case were found to be absent—as indeed they are, practically entirely, from Worcestershire waters. The *Total Hardness* is the sum of the permanent and temporary hardnesses, Nos. 15 and 16 in the above list. The Report Number of the County Analyst, and the Date, for each analysis, are given in the List of Analyses, see p. 183.

The following abbreviations are used :—

Bk.	Black.	N.v.c.	No visible change.
Bkg.	Blackening.	Ni.ox.	Oxides of nitrogen evolved.
Bn.	Brown.		
Bng.	Browning.	Op.	Opalescent.
Ch.W.	Chalybeate Water.	Ox.	Oxidising.
Cl.	Clear.	Pass., Ps.	Passable.
Dk.	Dark.	Sl.	Slight.
Dp.	Deposit.	St.	Strong.
Gd.	Good.	Stag.	Stagnant.
Gy.	Grey.	Susp.	Suspect.
Hd.	Hard.	Tr.	Trace.
Hv.	Heavy.	Unpl.	Unpleasant.
H_2S.	Odour of sulphuretted hydrogen.	V.	Very.
		Wh.	White.
M.W.	Mineral Water.	Yel.	Yellow.

A dash (—) signifies ' amount not determined ' or ' no information given.'

	1	2	3	4	5	6	7	8
1	Clear	Clear	Clear	Sl. op.	Sl. op.	Clear	Sl. op.	Clear
2	Nil	Nil	Nil	Sl. bn.	Sl. bn.	Si. bn.	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Nil	Tr.	Tr.	Tr.	Tr.	Tr.
5	26	37	29	31	28	36	280	55
6	White	White	White	White	Brown	White	White	White
7	21	28	25	24	23	29	228	36
8	Bkg.	N.v.c.	Sl. bkg.	N.v.c.	Sl. bkg.	Sl. bng.	N.v.c.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	4.1	6.3	4.0	5.3	1.9	4.9	9.3	3.7
11	0.0004	Nil	0.001	0.002	0.0008	0.004	Nil	0.004
12	0.001	0.001	0.004	0.004	0.006	0.008	0.004	0.006
13	0.01	0.04	0.04	0.01	0.05	0.02	0.02	0.01
14	Tr.	Nil	Nil	Tr.	Nil	Tr.	Tr.	0.4
15	5.1	8.6	6.3	6.0	1.8	4.0	68	19
16	5.8	10.5	7.1	5.3	14.6	12.5	29	20
17	Good	Good	Good	Good	Good	Good	M.W.	Good

	9	10	11	12	13	14	15	16
1	Clear	Clear	Clear	Clear	Clear	Sl. op.	Sl. op.	Sl. op.
2	Nil	Nil	Sl. gy.	V. sl. wh.	White	White	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	115	109	89	89	68	106	87	60
6	White	White	White	White	White	White	White	White
7	84	95	72	61	49	84	65	43
8	Bng.	Bng.	Sl. bng.	Sl. bk.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	17.5	17.7	13.5	14.6	7.5	22.1	3.2	2.6
11	Nil	0.001	0.0008	0.001	0.0006	0.008	0.007	0.0008
12	0.006	0.007	0.007	0.007	0.005	0.008	0.008	0.004
13	0.04	0.04	0.03	0.01	0.02	0.06	0.07	Nil
14	Nil	1.8	1.4	0.5	1.5	Tr.	Nil	Nil
15	29	17	18.5	13.5	11.5	19	21.8	16.5
16	29	39	28.5	23.5	16.0	18	27.2	20.5
17	Good	Pass.	Pass.	Good	Pass.	Good	Good	Good

	17	18	19	20	21	22	23	24
1	Sl. op.	Sl. op.	Clear	Clear	Clear	Clear	Sl. op.	Sl. op.
2	Sl. wh.	Sl. bn.	Brown	Brown	Brown	Nil	Sl. bn.	Sl. bn.
3	Sl.	Sl.	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Tr.
5	101	48	44	55	47	52	35	49
6	White	White	White	White	White	White	White	White
7	91	40	35	40	35	37	29	39
8	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	N.v.c.	N.v.c.	Bng.	Bn.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	7.4	3	1.5	3.7	2.8	5.8	2.5	1.6
11	0.0008	0.002	0.001	0.0006	0.0006	0.0006	0.0008	0.001
12	0.005	0.002	0.005	0.007	0.004	0.006	0.007	0.008
13	0.03	0.01	0.04	0.05	0.02	0.04	0.05	0.02
14	Nil	Nil	Tr.	1.0	0.1	0.4	Tr.	Nil
15	26	12.7	15.5	16.4	17.9	4.5	—	8
16	33	18.3	11.8	10.9	9.4	18.2	—	20
17	Good	Good	Good	Good	Good	Good	Good	Good

	25	26	27	28	29	30	31	32
1	Clear	Sl. op.	Sl. op.	Clear	Brown	Brown	Clear	Clear
2	Sl. bn.	Sl. wh.	Sl. wh.	Sl. bn.	Hv. bn.	Hv. bn.	Nil	Hv. bn.
3	Nil	Nil	Nil	Nil	Slight	Slight	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Hv. Tr.	Hv. Tr.	Nil	Tr.
5	62	32	57	43	41	44	73	24
6	White	White	White	White	Brown	Brown	White	White
7	49	23	41	32	29	36	60	18
8	N.v.c.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bkg.	Sl. bkg.	Sl. bkg.	Sl. bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.9	4.1	3.9	3.7	2.3	2.2	14.9	3.5
11	Nil	0.0006	0.002	Nil	0.0008	0.004	0.0008	0.0006
12	0.007	0.006	0.008	0.003	0.008	0.006	0.007	0.009
13	0.03	0.08	0.07	0.03	0.1	0.05	0.02	0.1
14	0.5	1.3	0.3	1.3	Nil	Nil	0.8	Nil
15	14.5	4.5	8.0	8.2	10.0	10.0	8.6	1.2
16	25.5	9.0	15.0	6.8	12.7	12.0	16.9	11.2
17	Good	Pass.	Good	Pass.	Iron dp.		Good	Pass.

	33	34	35	36	37	38	39	40
1	Clear	Clear	Clear	Clear	Clear	Clear	Sl. op.	Op.
2	Sl. yel.	Sl. bn.	Sl. wh.	Sl. bn.	Sl. wh.	Sl. wh.	Sl. wh.	Sl. wh.
3	Slight	Nil	Nil	Nil	Nil	Nil	Nil	Sl.
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	44	59	67	45	49	49	35	47
6	White	White	White	White	White	White	White	White
7	36	33	48	34	35	40	27	37
8	N.v.c.	Ni.ox.	Ni.ox.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.6	10.2	9.3	5.8	8.2	7.7	5.8	3.2
11	Nil	0.001	0.001	0.008	0.0006	0.0008	0.0008	0.002
12	0.003	0.007	0.005	0.008	0.004	0.004	0.002	0.005
13	0.1	0.03	0.01	0.03	Nil	0.04	0.03	0.05
14	Tr.	1.3	2.6	Tr.	Nil	Nil	Nil	Nil
15	10.0	10.9	16.0	22.5	13.5	12.7	10.0	9.0
16	6.0	9.1	11.0	5.0	12.5	16.4	12.7	12.0
17	Pass.	Pass.	Susp.	Good	Good	Good	Good	Good

	41	42	43	44	45	46	47	48
1	Sl. op.	Sl. op.	Clear	Sl. op.	Clear	Clear	Op.	V. Sl. op.
2	Sl. bn.	St. bn.	Sl. wh.	Sl. bn.	V. Sl. bn.	Sl. bn.	Sl. bn.	V. Sl.wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	53	45	41	43	32	77	46	78
6	White	White	White	White	White	White	White	White
7	40	36	37	38	30	56	34	61
8	Sl. bng.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Bng.	Bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	7.0	3.7	3.9	5.3	2.8	9.9	4.3	15.1
11	Nil	Nil	0.0008	0.002	Nil	0.0002	0.0008	0.001
12	0.004	0.007	0.006	0.004	0.001	0.003	0.005	0.006
13	0.01	0.02	0.01	0.02	Nil	Nil	Nil	0.01
14	Tr.	0.4	Nil	Nil	Nil	0.8	0.7	0.4
15	8.6	9.0	7.4	6.3	4.2	13.5	7.0	22.0
16	16.9	17.0	16.0	17.2	9.4	13.5	9.0	21.0
17	Good	Good	Good	Good	Good	Good	Good	Good

	49	50	51	52	53	54	55	56
1	Clear	Clear	V. Sl. op.	Sl. op.	Clear	Clear	Clear	Clear
2	Sl. bn.	Sl. bn.	Brown	Nil	Nil	Nil	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Nil	Nil	Tr.	Tr.
5	42	76	36	36	50	51	65	71
6	White	White	White	White	White	White	White	White
7	33	64	28	25	37	39	50	47
8	Sl. bng.	Bng.	Bng.	Sl. bng.	Bng.	Bng.	Sl. bkg.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.5	13.4	8.1	4.2	3.2	3.5	3.0	5.3
11	0.008	0.0008	0.001	Nil	0.0006	0.0008	0.001	0.002
12	0.005	0.004	0.007	0.002	0.006	0.006	0.006	0.008
13	0.03	0.02	0.02	0.02	0.04	0.02	0.04	0.04
14	Tr.	0.8	Tr.	Nil	Nil	Tr.	Nil	0.3
15	6.4	16.5	4.8	3.6	12.3	9.6	8.6	22.8
16	15.4	13.5	6.1	11.4	14.7	16.8	25.4	27.2
17	Good	Good	Pass.	Good	Good	Good	Good	Good

	57	58	59	60	61	62	63	64
1	Sl. op.	Sl. op.	Sl. op.	Clear	Clear	Sl. op.	Clear	Clear
2	Sl. bn.	Sl. bn.	Sl. wh.	V. sl. bn.	Sl. bn.	Sl. bn.	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Nil
5	117	40	26	34	62	33	18	18
6	White	White	White	White	White	White	White	White
7	96	31	21	29	44	28	14	11
8	Bkg.	N.v.c.	Sl. bk.	Sl. bk.	Sl. bk.	Bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	4.9	2.1	4.2	6.4	8.1	1.5	2.2	2.3
11	0.005	0.0004	0.008	0.001	0.002	0.003	0.001	0.001
12	0.009	0.001	0.009	0.009	0.009	0.01	0.003	0.001
13	0.04	Nil	0.06	0.07	0.05	0.08	0.006	0.01
14	Nil	Tr.	Tr.	Nil	Nil	Nil	Tr.	Nil
15	29.0	13.2	1.6	3.5	30.0	7.4	2.5	1.8
16	15.0	10.8	7.0	10.0		8.6	6.0	2.7
17	Good	Good	Good	Good	Good	Pass.	Good	Good

	65	66	67	68	69	70	71	72
1	Clear	Clear	Clear	Clear	Clear	Clear	Sl. op.	Op.
2	Nil	Nil	V. sl. wh.	V. sl.	Nil	Nil	Sl. bn.	Sl. yel.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Tr.	Tr.	Nil	Nil	Tr.	Tr.
5	12	20	17	19	12	17	17	44
6	White	White	White	White	White	White	White	White
7	8	16	13	12	10	14	13	32
8	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Sl. bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.5	2.1	2.5	2.3	2.4	1.9	2.3	16.3
11	0.001	Nil	0.0008	0.0008	0.002	0.002	0.0008	0.008
12	0.002	0.001	0.0006	0.003	0.001	0.002	0.002	0.01
13	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.04
14	Nil	Tr.	Nil	Nil	Tr.	0.2	Tr.	Nil
15	1.9	2.2	2.3	3.1	2.4	2.3	2.5	9.0
16	3.7	2.7	2.8	2.9	3.2	5.5	3.5	4.5
17	Good	Good	Good	Good	Good	Good	Good	Pass.

	73	74	75	76	77	78	79	80
1	Sl. op.	Op.	V. sl. op.	Op.	Sl. op.	Clear	Clear	Clear
2	Sl. wh.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Nil	Nil
3	Slight	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Nil
5	254	28	59	15	19	47	40	79
6	White	White	White	White	White	White	White	White
7	213	17	44	11	16	42	31	65
8	Ni. ox.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Tr.	Nil
10	61.3	7.0	11.2	4.3	1.9	8.7	5.1	9.9
11	0.002	0.006	0.0006	0.004	0.006	0.002	Nil	0.0006
12	0.01	0.006	0.002	0.005	0.009	0.003	0.003	0.007
13	0.04	0.02	Nil	0.02	0.04	Nil	0.006	0.03
14	7.2	Nil	Nil	Nil	0.2	0.5	Tr.	Nil
15	27.0	5.0	7.5	4.3	4.7	5.5	1.5	9.0
16	20.0	8.5	16.0	2.9	1.5	12.7	16.5	23.0
17	Bad	Good	Good	Good	Good	Good	Good	Good

	81	82	83	84	85	86	87	88
1	Clear	Clear	Clear	Op.	Clear	Sl. op.	Sl. op.	Sl. op.
2	Sl. wh.	Sl. yel.	Nil	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Nil	Tr.	Tr.	Tr.	Tr.	Tr.
5	62	75	93	51	56	130	87	82
6	White	Yel.	White	White	White	White	White	White
7	48	63	76	36	42	108	73	68
8	Sl. bng.	Ni.ox.	Sl. bng.	Bng.	Bkg.	Bkg.	Bkg.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.4	8.7	8.1	6.3	8.1	23.9	12.2	13.4
11	0.001	0.0008	Nil	0.006	0.0008	0.02	0.02	0.003
12	0.005	0.01	0.006	0.009	0.009	0.009	0.008	0.002
13	0.01	0.06	0.02	0.06	0.08	0.08	0.05	0.02
14	0.7	1.6	1.5	Tr.	Nil	Nil	Nil	Nil
15	13.5	11.3	18.2	10.9	13.6	13.2	13.6	11.8
16	18.5	16.0	18.8	10.1	16.4	25.8	25.4	26.2
17	Good	—	Pass.	Good	Good	—	—	—

	89	90	91	92	93	94	95	96
1	Sl. op.	Clear	Clear	Clear	Clear	Clear	Op.	Clear
2	Sl. bn.	Sl. bn.	Nil	Nil	Nil	Nil	Sl. bn.	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Nil	Nil	Nil	Nil	Tr.	Nil
5	413	23	17	18	21	20	53	45
6	White	White	White	White	White	White	White	White
7	380	17	14	14	17	17	45	39
8	Ni.ox.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	289.6	1.9	2.3	2.3	2.3	2.2	2.3	2.8
11	0.04	0.001	0.0008	0.002	0.0008	0.0008	0.0008	0.0006
12	0.01	0.003	0.002	0.002	0.0008	0.001	0.006	0.003
13	0.1	Nil	Nil	Nil	0.01	Nil	0.03	Nil
14	1.8	Tr.	Nil	Nil	Nil	0.2	Tr.	Tr.
15	36.0	3.5	3.9	2.3	3.0	2.9	6.4	7.0
16	26.0	7.0	5.1	8.1	7.6	8.3	23.1	19.0
17	M.W.	Good	Good	Good	Good	Good	Good	Good

	97	98	99	100	101	102	103	104
1	Clear	Clear	Clear	Sl. op.	Sl. op.	Clear	Clear	Clear
2	Nil	Nil	Nil	Sl. bn.	Hv. bn.	Sl. bn.	Nil	V. sl wh.
3	Nil	Nil	Nil	Nil	Slight	Nil	Nil	Nil
4	Nil	Nil	Tr.	Tr.	Hv. tr.	Tr.	Nil	Tr.
5	47	41	33	27	23	50	30	95
6	White	White	White	White	White	White	White	White
7	40	33	23	20	18	42	22	78
8	N.v.c.	N.v.c.	N.v.c.	Bng.	Sl. bng.	Sl. bng.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	3.2	2.3	2.0	2.3	1.6	6.1	3.2	32.7
11	0.0006	0.002	0.002	0.002	0.0008	0.001	0.002	0.001
12	0.002	0.008	0.002	0.007	0.006	0.01	0.002	0.005
13	0.007	0.04	Nil	0.04	0.03	0.2	0.04	0.01
14	Tr.	Nil	Nil	Tr.	Nil	Nil	Tr.	Tr.
15	7.0	8.2	4.4	2.9	4.7	11.0	1.6	9.0
16	20.0	11.3	15.1	10.7	5.7	16.3	10.6	28.0
17	Good	Good	Good	Good	Good	Pass.	Good	Good

	105	106	107	108	109	110	111	112
1	Sl. op.	Clear	Clear	V. st. op.	Clear	Clear	Op.	Clear
2	V. sl. wh.	Sl. bn.	Sl. bn.	Sl. bn.	Nil	Sl. bn.	Sl. wh.	V. sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	69	298	47	49	55	44	545	61
6	White	White	White	White	White	White	White	White
7	44	241	41	43	46	38	509	50
8	Sl. bng.	Sl. bng.	N.v.c.	Bng.	Bng.	N.v.c.	Bkg.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	6.3	56.0	5.3	2.3	3.0	1.6	173.4	4.0
11	0.001	0.007	0.001	0.004	0.001	0.0006	0.2	0.0008
12	0.006	0.01	0.004	0.007	0.007	0.006	0.007	0.01
13	0.06	0.05	0.02	0.02	0.01	0.02	0.1	0.04
14	Tr.	Nil	Tr.	Nil	Tr.	0.4	Nil	1.6
15	10.0	105.0	6.4	6.4	6.8	5.6	7.0	6.6
16	23.0	37.4	17.1	14.5	20.5	20.4	11.0	15.4
17	Good	M.W.	Good	Good	Good	Good	M.W.	Susp.

	113	114	115	116	117	118	119	120
1	Clear	Sl. op.	Clear	Clear	Clear	Clear	Clear	Clear
2	Nil	Sl. wh.	Sl. gy.	Sl. wh.	Nil	V. sl. wh.	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Tr.	Tr.	Tr.	Nil	Tr.	Nil	Nil
5	68	55	51	24	31	28	22	29
6	White	White	White	White	White	White	White	White
7	54	43	44	20	25	23	18	24
8	Sl. bk.	Bng.	Bng.	Sl. bng.	N.v.c.	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	4.6	3.9	2.5	3.0	2.6	3.2	2.1	3.7
11	Nil	0.0008	0.001	0.002	0.0008	0.0008	Nil	0.001
12	0.004	0.002	0.006	0.004	0.001	0.002	0.0008	0.008
13	0.01	Nil	0.01	Nil	Nil	Nil	Nil	0.01
14	0.3	Nil	Nil	Tr.	Tr.	Tr.	Nil	0.3
15	8.6	10.0	9.8	4.4	4.4	4.4	2.8	4.2
16	15.9	21.0	23.7	10.6	12.1	9.7	10.8	10.3
17	—	Good	Good	Good	Good	Good	Good	Good

	121	122	123	124	125	126	127	128
1	Clear	Clear	Clear	Clear	Clear	Clear	Op.	Clear
2	Nil	Nil	Nil	Nil	Sl. bn.	Nil	Sl. wh.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Nil	Nil	Tr.	Nil	Tr.	Tr.
5	26	34	25	23	60	46	996	68
6	White	White	White	White	White	White	White	White
7	22	29	19	18	48	38	964	56
8	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Ni. ox.	N.v.c.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.3	3.9	3.1	3.1	8.1	5.8	238	6.3
11	0.0008	0.002	0.001	0.002	0.0008	0.003	0.2	0.0008
12	0.002	0.004	0.001	0.002	0.004	0.006	0.007	0.006
13	Nil	Nil	Nil	0.01	0.02	0.01	0.04	0.03
14	Tr.	Tr.	Tr.	Nil	1.4	0.9	Nil	Tr.
15	3.0	5.0	3.0	4.5	10.9	8.0	32.0	9.1
16	9.3	9.5	7.9	5.5	18.2	13.0	25.0	19.1
17	Good	Good	Good	Good	Pass.	Good	M.W.	Good

	129	130	131	132	133	134	135	136
1	Clear	Clear	Clear	Clear	Clear	Sl. op.	Clear	Clear
2	V. st. wh.	Nil	Nil	Nil	Nil	Sl. wh.	Nil	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Nil	Nil	Nil	Nil	Tr.	Tr.	Tr.
5	72	93	74	100	70	55	76	67
6	White	White	White	White	White	White	White	White
7	51	78	56	87	58	32	58	55
8	Sl. bkg.	Sl. bng.	Sl. bkg.	Sl. bng.	Sl. bng.	Bng.	N.v.c	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tr.
10	6.4	4.6	9.3	6.3	7.0	3.5	5.3	3.5
11	Nil	Nil	0.01	0.01	0.001	Nil	0.001	0.0008
12	0.007	0.007	0.006	0.006	0.009	0.005	0.008	0.01
13	0.01	0.06	0.04	0.03	0.07	0.003	0.03	0.06
14	Tr.	Tr.	Nil	Tr.	Nil	Nil	1.0	Tr.
15	14.5	19.1	8.2	26.0	13.5	10.0	13.6	1.2
16	20.5	22.9	23.8	26.0	12.0	12.0	33.3	28.8
17	Good	Good	—	—	Good	Good	Pass.	Susp.

	137	138	139	140	141	142	143	144
1	Clear	Clear	Clear	Sl. bn.	Clear	Clear	Clear	Sl. op.
2	Nil	Sl. bn.	V. sl. bn.	Sl. yel.	Sl. wh.	Sl. bn.	Sl. bn.	V. st. wh.
3	Nil	Nil	Nil	Slight	Nil	Nil	Nil	Nil
4	Nil	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	82	60	45	51	37	42	38	32
6	White	White	White	White	White	White	White	White
7	64	50	37	34	25	33	32	25
8	Bng.	N.v.c.	N.v.c.	N.v.c.	Bng.	N.v.c.	Bng.	N.v.c.
9	Nil	Nil	Nil	Tr.	Nil	Nil	Nil	Nil
10	9.9	9.5	3.2	3.0	2.4	3.5	3.9	3.5
11	Nil	0.002	0.0008	0.003	0.0008	0.002	0.003	Nil
12	0.008	0.003	0.006	0.01	0.008	0.008	0.006	0.002
13	0.02	0.01	0.02	0.1	0.08	0.03	0.05	0.02
14	Tr.	0.7	Tr.	Tr.	Tr.	0.7	Tr.	0.6
15	21.8	12.7	5.6	12.7	7.7	8.2	5.4	4.2
16	23.2	10.9	10.4	14.6	14.3	14.3	9.6	7.2
17	Good	Good	Good	—	Good	Good	—	Good

	145	146	147	148	149	150	151	152
1	Sl. op.	Clear	Sl. op.	Clear	Clear	Sl. op.	Sl. op.	Op.
2	Sl. bn.	Sl. bn.	V. st.wh.	Sl. yel.	Nil	Sl. wh.	Sl. wh.	Dk. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Nil	Hv. tr.
5	37	64	64	127	57	109	167	416
6	White	White	White	White	White	White	White	White
7	26	58	53	101	48	88	138	394
8	Sl. bkg.	N.v.c.	Sl. bk.	Sl. bk.	Bng.	Sl. bk.	Sl. bk.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	3.0	3.5	8.1	11.0	2.8	3.8	8.7	272.1
11	0.0004	0.002	0.001	0.0006	0.003	0.002	0.0008	0.22
12	0.003	0.003	0.006	0.008	0.005	0.01	0.006	0.01
13	0.02	Nil	0.02	0.04	0.02	0.02	0.02	0.06
14	Tr.	Nil	0.6	0.3	Nil	Nil	Nil	Nil
15	4.5	9.4	9.5	32.0	17.0	22.7	47.0	23.0
16	13.5	10.9	15.0	13.0	10.3	18.3	19.0	20.0
17	Good	Good	Good	Good	Good	Good	Gd. Hd.	M.W.

	153	154	155	156	157	158	159	160
1	Clear	Sl. op.	Sl. op.	Clear	Sl. op.	Clear	Clear	Sl. op.
2	Sl. bn.	Sl. bn.	V. sl. bn.	V. st. wh.	Bn.	Bn.	Nil	V. st. wh.
3	Sl. stag.	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	77	95	41	49	40	67	52	58
6	White	White	White	White	White	White	White	White
7	66	78	38	39	30	57	44	41
8	Sl. bng.	Sl. bng.	Bng.	Sl. bng.	N.v.c.	Sl. bng.	N.v.c.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	7.0	7.4	3.8	3.2	4.0	4.2	3.1	3.7
11	Nil	0.003	0.001	0.0008	0.0008	0.0008	0.0008	0.002
12	0.006	0.004	0.006	0.006	0.006	0.004	0.006	0.006
13	0.07	0.03	0.02	0.03	0.03	0.01	0.02	0.05
14	Nil	Tr.	1.2	Nil	0.4	Nil	Nil	Nil
15	14.5	25.5	6.3	12.7	5.8	9.5	10.9	10.0
16	19.5	21.5	5.1	14.6	9.7	23.5	18.1	16.4
17	—	Good	Good	Good	Good	Good	Good	Good

	161	162	163	164	165	166	167	168
1	Clear	Clear	Sl. op.	Clear	Clear	V. st. op.	V. st. op.	V. st. op.
2	V. st. wh.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. yel.	Sl. wh.	Sl. wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Stag.	BadH_2S.
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Hv. bn.
5	49	37	39	28	32	478	454	383
6	White	White	White	White	White	White	White	Bn.
7	34	32	34	24	26	362	377	322
8	N.v.c.	N.v.c.	Sl. bk.	N.v.c.	N.v.c.	Bng.	N.v.c.	Got dk.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.0	2.2	3.0	2.1	2.9	8.1	8.7	23.3
11	0.0008	Nil	0.0008	0.0008	0.004	0.001	0.001	0.0006
12	0.004	0.0006	0.02	0.002	0.01	0.004	0.004	0.006
13	Nil	Nil	0.04	0.01	0.06	Nil	0.01	0.1
14	Nil	Nil	Tr.	Nil	Nil	Nil	Nil	Nil
15	11.5	3.3	2.5	1.9	2.0	152.0	165.0	150.0
16	11.5	11.2	17.0	10.3	11.2	33.0	5.0	30.0
17	Good	Good	—	Good	—	M.W.	M.W.	M.W.

	169	170	171	172	173	174	175	176
1	Clear	Sl. op.	Op.	Clear	Clear	Clear	Op.	V. St. op.
2	Bn.	Sl. bn.	V. st. wh.	V. st. wh.	Sl. bn.	Sl. bn.	V. st. wh.	V. st. bn.
3	Bad	Nil	Nil	Nil	Nil	Nil	Earthy	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	276	59	227	95	50	77	95	225
6	Bn.	White	White	White	White	White	White	White
7	204	39	181	83	42	70	64	166
8	Bkg.	Sl. bk.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Ni. ox	Ni. ox.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	46.7	1.8	13.4	9.3	2.9	9.3	13.4	46.7
11	0.002	0.0006	0.001	0.006	0.0006	0.001	0.002	0.001
12	0.009	0.007	0.005	0.006	0.003	0.007	0.007	0.01
13	0.1	0.02	0.02	Nil	0.01	0.01	0.02	0.06
14	Nil	Nil	Nil	Nil	Nil	Nil	1.1	1.4
15	90.0	17.3	62.0	21.8	10.0	14.5	23.0	43.0
16	42.0	22.7	43.0	21.2	21.0	20.5	18.0	21.0
17	M.W.	Good	V. hd.	Good	Good	Good	Pass.	—

	177	178	179	180	181	182	183	184
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Sl. op.
2	Sl. bn.	Nil	Nil	Nil	Nil	Sl. wh.	V. st. bn.	V. st. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Nil	Nil	Nil	Nil	Tr.	Tr.	Tr.
5	53	225	63	63	63	60	348	254
6	White	White	White	White	White	White	White	White
7	39	178	49	47	50	53	305	209
8	Sl. bng.	Sl. bng.	N.v.c.	Sl. bng.	Sl. bng.	Sl. bkg.	Sl. bk.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	4.4	18.6	4.9	4.4	4.6	8.8	14.0	2.9
11	Nil	0.001	0.0006	0.0008	0.0008	0.001	0.004	0.005
12	0.003	0.004	0.002	0.004	0.006	0.008	0.006	0.01
13	0.01	0.04	Nil	Nil	0.01	0.04	0.02	0.07
14	0.5	Nil	Nil	Nil	Nil	Nil	Nil	0.3
15	11.0	73.0	16.5	19.5	17.5	2.0	} 157.0	94.0
16	14.5	32.0	20.5	16.5	21.1	19.8		11.0
17	Good	M.W.	Good	Good	Good	Good	M.W.	—

	185	186	187	188	189	190	191	192
1	Clear	Op.	Clear	Op.	Op.	Op.	Clear	Sl. op.
2	V. st. bn.	Sl. yel.	Sl. bn.	Sl. bk.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. wh.
3	H_2S.	Slight	Nil	St. H_2S.	St. H_2S.	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	850	106	88	294	303	50	44	64
6	White	White	White	White	White	Brown	White	White
7	778	73	70	253	261	40	34	56
8	Sl. bk.	Sl. bk.	N.v.c.	Bk. fetid	Bk. fetid	Bkg.	N.v.c.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	408.8	15.1	5.2	1.6	3.0	2.5	3.5	7.5
11	0.3	0.01	0.0008	—	0.7	0.02	0.002	0.001
12	0.01	0.009	0.007	—	0.05	0.01	0.003	0.004
13	0.04	0.04	0.01	—	2.2	0.09	Nil	0.02
14	Nil	Tr.	0.2	—	Nil	Tr.	Tr.	Tr.
15	} 310.0	18.0	23.5	—	70.0	10.0	8.2	16.0
16		29.0	28.5	—	62.0	19.0	16.4	11.0
17	M.W.	Susp.	Good	—	—	—	Good	Good

	193	194	195	196	197	198	199	200
1	Clear	Sl. op.	Sl. op.	Clear	Sl. op.	Sl. op.	Clear	Op.
2	Sl. wh.	Sl. bn.	Sl. bn.	Nil	Nil	Sl. bn.	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Sl. Stag.	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	66	43	37	119	108	78	42	238
6	White	White	White	White	White	White	White	White
7	55	35	29	105	85	66	37	202
8	Sl.bng.	Bng.	Bng.	N.v.c.	Sl. bn.	Sl. bng.	Bng.	Sl. bn.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	9.3	4.4	4.9	10.5	9.9	10.5	3.3	9.3
11	0.01	0.001	0.0008	0.03	0.004	0.0008	0.0006	0.0006
12	0.002	0.006	0.002	0.002	0.005	0.005	0.008	0.006
13	0.04	0.02	0.02	0.01	0.02	0.02	0.012	0.03
14	Nil	Nil	Nil	Tr.	Nil	0.9	Nil	0.6
15	9.0	7.3	6.4	28.4	23.0	15.5	4.4	62.0
16	16.5	10.0	12.7	19.6	17.0	18.5	16.6	30.5
17	Pass.	Good	Good	—	Good	Good	Good	M.W.

	201	202	203	204	205	206	207	208
1	Op.	Clear	Op.	Clear	Op.	Clear	Clear	Clear
2	Sl. bn.	V. st. wh.	Sl. bn.	Nil	Sl. bn.	V. st. bn.	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Nil	Tr.	Tr.	Nil	Nil
5	303	33	45	21	454	23	17	26
6	White	White	White	White	White	White	White	White
7	277	25	33	15	427	17	15	21
8	Sl. bn.	Sl. bng.	Sl. bng.	Sl. bng.	Melting	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	242.3	3.8	4.6	2.7	268.0	2.3	2.3	2.5
11	0.007	0.001	0.002	0.003	0.08	Nil	0.001	0.0006
12	0.009	0.005	0.005	0.003	0.007	0.001	0.002	0.002
13	0.04	0.01	Nil	Nil	0.03	0.006	Nil	Nil
14	Tr.	Tr.	Nil	Nil	Nil	Nil	0.2	Nil
15	24.6	13.5	16.0	3.5	54.0	2.4	2.3	2.7
16	11.9	4.5	10.5	6.0	37.0	6.0	6.1	9.6
17	M.W.	Good	Good	Good	Salt	Good	Good	Good

	209	210	211	212	213	214	215	216
1	Clear	Clear	Clear	Clear	Clear	Clear	Sl. op.	Sl. op.
2	Nil	Nil	Nil	Nil	Nil	V. st. wh.	V. st. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Sl. H_2S.
4	Nil	Nil	Nil	Nil	Nil	Tr.	Tr.	Tr.
5	28	20	27	17	19	68	86	75
6	White	White	White	White	White	White	White	White
7	24	18	23	14	16	57	64	57
8	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Bkg.	Sl. bng.	Sl. bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.5	3.0	2.9	2.5	2.5	11.0	12.2	7.5
11	0.0008	0.0008	0.001	0.0006	0.0006	0.01	Nil	0.004
12	0.0008	0.001	0.002	0.0008	0.001	0.008	0.009	0.008
13	Nil	Nil	Nil	Nil	Nil	0.1	0.08	0.1
14	0.5	Nil	0.3	0.3	0.3	Tr.	1.2	Tr.
15	3.2	2.8	2.7	2.4	2.3	9.0	18.0	12.0
16	9.2	7.3	7.3	5.0	5.5	14.0	19.0	26.0
17	Good	Good	Good	Good	Good	Pass.	Pass.	Pass.

	217	218	219	220	221	222	223	224
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
2	Sl. wh.	Sl. bn.	Nil	Nil	Nil	Nil	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Nil	Nil	Nil	Nil	Nil	Nil
5	104	78	26	19	22	28	22	26
6	White	White	White	White	White	White	White	White
7	79	58	20	15	20	24	19	21
8	N.v.c.	Sl. bng.	Sl. bng.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	9.9	7.2	2.0	2.0	1.9	1.9	1.9	2.2
11	0.0008	0.0006	Nil	0.0006	0.0008	0.0006	0.001	0.0008
12	0.006	0.006	0.001	0.002	0.001	0.001	0.001	0.001
13	0.04	0.02	Nil	Nil	0.01	Nil	Nil	Nil
14	Tr.	Nil	Tr.	Tr.	Tr.	Tr.	0.2	Tr.
15	19.0	23.0	2.5	2.7	2.6	3.7	3.4	2.7
16	22.0	26.0	9.3	7.7	9.2	9.7	8.6	9.6
17	Good	Good	Good	Good	Good	Good	Good	Good

	225	226	227	228	229	230	231	232
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
2	Nil	Nil	V. st. wh.	V. st. wh.	Nil	Nil	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Tr.	Tr.	Nil	Nil	Nil	Nil
5	24	28	79	76	21	27	18	29
6	White	White	White	White	White	White	White	White
7	21	22	65	62	17	23	15	24
8	N.v.c.	N.v.c.	Bng.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	1.9	1.9	14.0	7.7	2.0	1.8	2.1	2.2
11	0.0008	0.0008	0.003	0.001	0.001	0.0008	0.02	0.002
12	0.0006	0.001	0.006	0.006	0.001	0.004	0.004	0.001
13	Nil	Nil	0.06	0.03	Nil	0.006	0.01	Nil
14	Tr.	Tr.	Nil	0.4	Tr.	Tr.	Nil	Tr.
15	2.8	2.7	9.0	21.0	3.1	3.2	2.9	3.7
16	9.9	10.0	18.0	24.0	8.7	9.4	6.9	8.1
17	Good	Good	Good	Good	Good	Good	Good	Good

	233	234	235	236	237	238	239	240
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Sl. op.
2	Nil	Nil	Nil	Nil	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Nil	Nil	Tr.	Tr.	Tr.	Tr.
5	30	27	25	24	54	167	68	38
6	White	White	White	White	White	White	White	White
7	26	22	21	20	42	143	58	31
8	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Sl.bng.	Sl. bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.1	2.2	2.2	2.2	2.0	14.0	2.8	3.0
11	0.001	0.004	0.001	0.001	Nil	0.001	0.001	0.0006
12	0.003	0.007	0.001	0.002	0.006	0.007	0.007	0.009
13	0.01	Nil	Nil	Nil	0.03	0.04	0.02	0.02
14	Tr.	Tr.	Tr.	Tr.	Nil	Nil	0.8	Tr.
15	3.2	2.9	3.1	3.0	12.3	53.0	3.1	5.4
16	10.0	9.4	9.6	7.0	16.8	34.5	22.4	15.6
17	Good	Good	Good	Good	Good	Pass.Hd	Good	Good

	241	242	243	244	245	246	247	248
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
2	Nil	Nil	Nil	V. sl.wh.	Nil	Nil	Sl. yel.	Sl. yel.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Nil	Tr.	Nil	Nil	Nil	Nil
5	50	62	27	69	29	45	47	85
6	White	White	White	White	Yellow	White	Yellow	White
7	41	50	23	52	21	29	29	61
8	Sl. bng.	N.v.c.	Sl. bk.	Bng.	Bng.	Bng.	Bng.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	3.5	6.5	5.1	11.0	5.3	7.0	8.1	8.1
11	0.0006	0.002	0.0008	0.0008	Nil	Nil	0.001	0.001
12	0.006	0.006	0.004	0.008	0.004	0.003	0.003	0.004
13	0.02	0.02	0.04	0.02	0.01	0.02	0.04	0.04
14	0.5	0.9	Nil	Tr.	1.0	Tr.	Tr.	0.8
15	7.4	15.0	6.5	13.5	4.5	9.0	7.0	18.0
16	21.6	21.0	12.0	18.5	7.0	14.0	11.0	21.0
17	Good	Good	Good	Good	Good	Good	Good	Good

	249	250	251	252	253	254	255	256
1	Clear	Op.	Clear	Clear	Op.	Op.	Clear	Clear
2	Sl. bn.	V. st.wh.	V. st.wh.	Sl. bn.	Sl. bn.	Sl. bn.	Nil	V. st.wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	H_2S
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Tr.
5	68	70	97	57	50	48	73	436
6	White	White	White	White	White	White	White	White
7	48	61	81	40	42	38	58	383
8	Bng.	Sl. bk.	Sl. bng.	Sl. bkg.	Sl. bng.	Sl. bng.	Sl. bng.	Melted
9	Nil	Nil	Tr.	Nil	Nil	Nil	Nil	Nil
10	14.6	7.5	10.5	3.1	5.1	4.4	11.9	64.8
11	0.0008	0.002	0.002	0.0008	0.001	0.0008	0.0008	0.006
12	0.009	0.009	0.01	0.005	0.007	0.006	0.006	0.003
13	0.03	0.02	0.05	0.03	0.01	0.04	0.04	0.01
14	0.4	0.7	2.1	0.9	0.3	0.3	Tr.	Nil
15	19.5	18.0	9.0	13.2	5.1	8.2	16.0	120.0
16	6.9	24.0	33.0	15.9	17.4	15.5	19.0	27.5
17	Good	Good	Susp.	Good	Good	Good	Good	M.W.

	257	258	259	260	261	262	263	264
1	Sl. op.	Clear	Clear	Sl. op.	V. sl. op.	Sl. op.	Sl. op.	Sl. op.
2	V. st.wh.	V. st.yel.	V. st. bn.	Sl. wh.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. wh.
3	Nil	Nil	Nil	Sl. stag.	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Hv. tr.	Tr.	Tr.	Tr.	Tr.
5	376	124	21	38	24	229	92	80
6	White	White	White	White	White	White	White	White
7	312	97	13	30	15	186	72	65
8	Melted	Bk.	Sl. bk.	Sl. bng.	Sl. bng.	Sl. bkg.	Sl. bkg.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	33.2	31.5	2.3	3.0	2.5	20.4	15.7	5.1
11	0.005	Nil	0.001	0.001	0.002	0.01	0.004	0.01
12	0.01	0.01	0.004	0.006	0.008	0.009	0.01	0.01
13	0.09	0.06	0.02	0.02	0.04	0.04	0.09	0.03
14	Tr.	Nil.	Tr.	Nil	Nil	Nil	Tr.	Nil
15	97.5	24.6	3.9	6.5	4.9	62.0	18.2	23.0
16	32.5	11.4	3.7	11.0	9.5	55.0	22.8	14.0
17	M.W.	Pass.	Good	Good	Good	Ch.W.	Pass.	—

	265	266	267	268	269	270	271	272
1	Sl. op.	Sl. op.	Clear	Clear	Clear	Clear	Clear	Clear
2	Nil	Sl. bn.	Sl. bn.	Sl. bn.	V. st. yel.	Nil	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Tr.
5	547	40	29	36	33	36	32	24
6	White	White	White	White	White	White	White	White
7	522	27	26	26	27	31	28	19
8	Melted	Bng.	Sl. bng.	Bng.	Bng.	Sl. bng.	Bng.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	140.1	4.2	3.7	3.7	3.1	3.2	2.8	2.4
11	0.03	0.0008	0.001	0.0008	0.002	0.0008	Nil	Nil
12	0.04	0.007	0.004	0.007	0.007	0.001	0.004	0.0002
13	0.1	0.04	0.03	0.05	0.01	Nil	0.01	Nil
14	Tr.	Tr.	Nil	Nil	Nil	Nil	Nil	Nil
15	66.0	3.5	1.8	2.7	7.0	4.0	3.4	2.0
16	26.0	19.5	13.2	14.3	9.0	12.0	12.6	8.9
17	M.W.	Good	Good	Good	Good	Good	Good	Good

	273	274	275	276	277	278	279	280
1	Sl. op.	Clear	Clear	Op.	Clear	Clear	Clear	Clear
2	Sl. bn.	Sl. bn.	V. st.wh.	Sl. bn.	Nil	Nil	Nil	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Nil	Nil	Nil	Nil
5	7	33	54	30	77	67	65	57
6	White	White	White	White	White	White	White	White
7	5	26	47	22	44	50	44	47
8	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Bng.	Bng.	Bng.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	1.1	9.3	2.5	2.8	10.5	11.6	3.5	1.8
11	0.002	0.002	0.001	0.004	0.0006	Nil	0.002	0.0008
12	0.01	0.009	0.005	0.01	0.006	0.006	0.008	0.002
13	0.08	0.08	0.01	0.06	0.04	0.02	0.08	0.02
14	Nil	Nil	Nil	Tr.	0.8	0.9	Nil	Tr.
15	0.5	4.5	11.0	5.9	14.1	16.4	16.0	33.0
16	1.5	9.0	16.0	6.8	20.9	23.6	23.0	22.0
17	Pass.	Pass.	Good	—	Good	Good	Good	Pass.

	281	282	283	284	285	286	287	288
1	Sl. op.	Clear	Clear	Op.	Sl. op.	Clear	Clear	Sl. op.
2	Sl. yel.	Nil	Nil	Sl. bn.	Sl. bn.	Sl. bn.	V. st.bn.	Sl. wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Nil	Nil	Tr.	Tr.	Tr.	Tr.	Tr.
5	85	56	67	461	30	60	66	216
6	White	White	Yellow	White	White	White	White	White
7	53	42	54	396	25	50	53	166
8	Bng.	Bkg.	Bkg.	Sl. bn.	N.v.c.	Bng.	N.v.c.	Ni. ox.
9	Nil	Tr.	Nil	Nil	Nil	Nil	Nil	Nil
10	7.5	2.9	4.7	24.5	4.3	11.0	10.5	59.0
11	Nil	0.001	0.004	0.0006	0.0006	Nil	0.0008	Nil
12	0.008	0.005	0.007	0.008	0.003	0.006	0.004	0.001
13	0.05	0.04	0.05	0.05	Nil	0.03	0.02	0.01
14	0.8	Nil	Nil	0.4	Tr.	1.5	1.4	2.0
15	18.0	11.5	11.0	102.0	4.2	7.3	12.4	62.0
16	44.0	19.5	20.0	83.0	9.0	15.4	19.1	30.5
17	Good	—	Good	M.W.	Good	Pass.	Pass.	V. hd.

	289	290	291	292	293	294	295	296
1	Sl. op.	Sl. op.	Clear	Sl. op.	Clear	Clear	Clear	V. st. op.
2	Sl. bn.	Nil	Sl. yel.	Nil	Sl. bn.	Nil	Sl. bn.	V. st. wh.
3	Sl. stag.	Nil	Nil	Nil	Nil	Nil	Nil	Slight
4	Tr.	Nil	Tr.	Nil	Tr.	Nil	Tr.	Tr.
5	69	55	54	58	62	72	222	59
6	White	White	White	White	White	White	White	White
7	46	46	43	46	44	52	200	43
8	Sl. bng.	N.v.c.	Sl. bkg.	N.v.c.	Bkg.	Bng.	Bng.	Sl. bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	11.6	4.0	5.6	6.5	5.3	8.1	20.4	5.1
11	0.0006	Nil	0.001	0.007	0.001	0.002	0.0008	0.0006
12	0.005	0.008	0.006	0.002	0.007	0.004	0.008	0.009
13	0.03	0.01	0.04	0.02	0.01	0.02	0.02	0.04
14	Nil	0.7	Nil	Nil	Nil	Tr.	Tr.	Nil
15	12.5	7.8	6.4	10.0	26.0	—	62.0	14.1
16	20.5	23.2	18.2	13.6	18.0	—	28.0	15.0
17	Good	Good	Good	Good	Good	Good	Good	Good

	297	298	299	300	301	302	303	304
1	Clear	Clear	Clear	Op.	Clear	Clear	Clear	Clear
2	Sl. bn.	Nil	Nil	Sl. wh.	Sl. yel.	Nil	V. st. wh.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Nil	Nil	Tr.	Tr.	Nil	Tr.	Tr.
5	35	34	56	55	95	52	38	42
6	White	White	White	White	White	White	White	White
7	25	24	40	39	74	29	30	29
8	Bng.	Bng.	Bng.	Sl. bk.	Sl. bng.	Sl. bng.	Sl. bng.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	3.0	2.0	5.0	2.9	7.2	3.5	2.4	3.5
11	0.0006	0.0008	0.003	0.002	0.001	0.003	0.003	0.001
12	0.008	0.006	0.01	0.008	0.008	0.006	0.004	0.01
13	0.08	0.05	0.06	0.04	0.06	0.04	0.03	0.02
14	0.7	Nil	Tr.	Tr.	Nil	Tr.	Nil	Nil
15	6.6	4.7	6.8	9.0	16.5	4.4	3.6	5.5
16	12.9	12.5	19.6	18.0	34.5	22.9	18.2	17.2
17	Pass.	Good	Pass.	Good	Good	Good	Good	—

	305	306	307	308	309	310	311	312
1	Clear	Clear	Sl. op.	Sl. op.	Clear	Clear	V. st. op.	Clear
2	Sl. bn.	Sl. bn.	Sl. yel.	Sl. bn.	Nil	Sl. bn.	Sl. wh.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Sl. stag.	Nil
4	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Tr.	Tr.
5	39	33	27	35	49	45	43	38
6	White	White	White	White	White	White	White	White
7	35	30	20	23	37	37	32	30
8	Bkg.	Bkg.	Sl. bk.	Sl. bng.	N.v.c.	Bng.	Sl. bng.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	3.1	2.5	3.7	3.3	4.0	4.9	4.4	3.9
11	0.001	0.002	0.003	0.001	0.002	0.0008	0.0008	0.002
12	0.002	0.001	0.008	0.004	0.002	0.007	0.004	0.006
13	0.01	0.01	0.09	0.02	0.01	0.02	0.02	0.02
14	Tr.	Tr.	0.7	0.6	Tr.	0.4	Tr.	Tr.
15	4.2	1.8	8.6	7.3	8.0	—	6.5	—
16	16.8	16.2	5.0	9.1	11.0	—	12.5	—
17	Good	Good	Good	Good	Good	Good	Good	Good

	313	314	315	316	317	318	319	320
1	Clear	Clear	Clear	Sl. op.	Clear	Sl. op.	Op.	Clear
2	V. sl. wh.	V. sl. wh.	Nil	Sl. bn.	Sl. bn.	Sl. wh.	V. st. wh.	V. st. bn.
3	Nil	Nil	Nil	Nil	Nil	Sl. H_2S.	Nil	Nil
4	Tr.	Tr.	Nil	Tr.	Tr.	Tr.	Tr.	Tr.
5	45	61	92	60	60	825	209	138
6	White	White	White	White	White	White	White	White
7	33	49	78	49	53	687	195	122
8	N.v.c.	Sl. bng.	Sl. bk.	Bkg.	Sl. bk.	Bkg.	Bng.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Tr.	Nil	Nil
10	6.7	8.4	9.3	6.3	9.9	93.4	14.6	48.4
11	0.001	Nil	0.002	0.0008	0.002	0.2	0.008	0.009
12	0.004	0.005	0.009	0.008	0.008	0.008	0.009	0.007
13	0.01	0.01	0.05	0.1	0.03	0.08	0.01	0.06
14	Tr.	0.3	Tr.	Tr.	0.4	Nil	Nil	Nil
15	8.2	7.3	19.1	11.8	13.6	310.0	49.0	17.5
16	10.0	13.6	12.7	15.5	17.4		3.0	17.5
17	Good	Good	Good	Good	Good	M.W.	Gd. M.W	Gd.M.W

	321	322	323	324	325	326	327	328
1	Clear	Sl. op.	Sl. op.	Sl. op.	Clear	Clear	Sl. op.	Sl. op.
2	V. st. bn.	V. st. wh.	V. st. wh.	V. st. wh.	Nil	Nil	V. st. bn.	V. st. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Unpl.
4	Tr.	Tr.	Tr.	Tr.	Nil	Nil	Tr.	Tr.
5	78	317	60	38	95	67	69	53
6	White	White	White	White	White	White	Sl. yel.	White
7	67	270	46	29	73	44	47.2	33
8	Sl. bkg.	N.v.c.	Sl. bk.	Sl. bng.	Sl. bng.	Ni. ox.	Bkg.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	8.7	16.9	5.1	4.7	33.2	6.5	9.3	1.6
11	0.007	0.1	0.006	0.001	0.0006	Nil	0.0008	0.004
12	0.007	0.008	0.008	0.004	0.003	0.003	0.007	0.008
13	0.04	0.04	0.04	0.03	Nil	Nil	0.02	0.02
14	Nil	Nil	Nil	1.1	Nil	1.6	1.7	Tr.
15	11.8	82.5	13.6	9.0	21.0	16.4	13.6	17.3
16	23.2	32.5	15.5	7.0	6.5	11.8	18.4	11.8
17	Good	—	Good	Pass.	Good	Good	Good	Good

	329	330	331	332	333	334	335	336
1	Sl. op.	Sl. op.	Clear	Clear	Clear	Clear	Clear	Clear
2	V. st. bn.	V. st. bn.	Nil	V. st. wh.	Nil	Sl. bn.	Nil	Nil
3	Nil	Nil	Nil	Nil	Slight	Nil	Nil	Nil
4	Tr.	Hv. tr.	Nil	Tr.	Nil	Tr.	Nil	Nil
5	82	377	85	328	302	55	161	95
6	White	White	White	White	White	White	White	White
7	65	348	69	269	264	38	133	77
8	Sl. bk.	Bkg.	Sl. bk.	N.v.c.	Sl. bn.	Sl. bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	14.6	233.0	12.8	18.1	14.0	8.1	12.2	7.5
11	0.003	0.0006	0.004	0.02	0.02	0.001	Nil	0.001
12	0.006	0.1	0.004	0.006	0.002	0.006	0.007	0.006
13	0.04	0.6	0.04	0.02	0.02	0.04	0.01	Nil
14	0.7	Nil	0.6	Nil	Nil	Tr.	0.9	0.3
15	20.0	43.0	16.0	62.0	63.0	9.0	37.0	26.0
16	25.0	34.5	26.0	68.0	52.0	9.0	30.0	15.0
17	Good	M.W.	Good	M.W.	M.W.	Good	Pass. hd.	Good

	337	338	339	340	341	342	343	344
1	Clear	Clear	Clear	Op.	Clear	Op.	Clear	Clear
2	Sl. bn.	Nil	Sl. bn.	Hv. bn.	Nil	Hv. bn.	Sl. bn	Nil
3	Nil	Nil	Nil	Slight	Nil	Slight	Nil	Nil
4	Tr.	Nil	Tr.	Hv. Tr.	Nil	Hv. Tr.	Tr.	Tr.
5	45	21	51	1530	91	70	188	94
6	White	White	White	Brown	White	Brown	White	White
7	38	18	42	1395	73	62	172	87
8	N.v.c.	N.v.c.	Bkg	N.v.c.	N.v.c.	Bng.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil.	Nil	Nil
10	2.8	3.7	7.4	759.0	10.5	9.1	147.1	54.0
11	0.003	0.0006	0.0006	0.27	0.0006	0.002	0.008	—
12	0.006	0.003	0.008	0.01	0.006	0.008	0.002	—
13	0.03	Nil	0.02	0.05	0.04	0.1	Nil	—
14	Nil	Nil	0.3	Nil	1.4	Nil	Nil	—
15	8.6	2.3	8.6	296.0	20.0	0.6	9.1	—
16	20.9	7.3	15.1	68.0	17.0	17.6	12.7	—
17	Good	Good	Good	M.W.	Good	—	—	—

	345	346	347	348	349	350	351	352
1	Clear	Clear	Sl. op.	Clear	Sl. op.	Sl. op.	Clear	V. st. op.
2	Sl. bn.	V. st. wh.	Sl. bn.	V. st. bn.	V. st. bn.	V. st. wh.	Sl. yel.	Sl. yel.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	57	52	60	71	57	81	61	53
6	White	White	White	White	White	White	White	White
7	50	34	42	57	40	71	51	45
8	Bng.	Sl. bk.	N.v.c.	N.v.c.	N.v.c.	Bng.	Sl. bkg.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	7.4	3.9	5.2	10.5	5.6	14.0	9.9	4.4
11	0.0008	Nil	0.0006	0.0006	0.002	0.0006	0.002	0.001
12	0.006	0.004	0.004	0.002	0.002	0.007	0.006	0.009
13	0.01	0.01	0.02	Nil	0.03	0.06	0.04	0.02
14	1.2	Nil	Nil	Nil	Nil	0.9	Nil	Tr.
15	10.0	11.8	9.0	15.0	11.8	10.9	0.0	8.0
16	17.3	14.6	18.5	25.0	14.6	17.3	18.2	16.5
17	Good	Good	Good	Good	Good	Good	Good	Good

	353	354	355	356	357	358	359	360
1	Op.	Clear	Op.	Clear	Clear	Clear	Clear	Clear
2	Sl. wh.	Sl. bn.	Brown	Sl. bn.	Sl. bn.	Sl. yel.	Sl. wh.	Nil
3	Earthy	Earthy	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Nil
5	322	45	41	34	75	18	17	16
6	White	White	White	White	White	White	White	White
7	263	38	33	24	50	11	13	12
8	N.v.c.	Sl. bng.	Sl. bng.	Bkg.	Sl. bng.	Sl. bng.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	8.1	3.6	1.9	3.5	6.5	2.7	3.2	2.6
11	Nil	0.0008	0.002	0.002	0.005	0.003	Nil	0.002
12	0.009	0.002	0.008	0.008	0.008	0.002	0.001	0.004
13	0.03	0.02	0.04	0.01	0.02	Nil	Nil	Nil
14	Tr.	Nil	Nil	Tr.	0.4	Nil	Tr.	Nil
15	105.0	7.3	7.7	5.6	21.0	3.4	2.9	2.2
16	30.0	10.7	10.3	8.5	21.0	5.7	4.7	3.7
17	M.W.	Good	Good	Good	Good	Good	Good	Good

	361	362	363	364	365	366	367	368
1	Clear	Sl. op.	Clear	Clear	Clear	Clear	Clear	Op.
2	Nil	Sl. bn.	Nil	Nil	Nil	Nil	Sl. bk.	Brown
3	Nil	Nil	Nil	Nil	Nil	Nil	Sooty	Nil
4	Nil	Tr.	Nil	Nil	Nil	Nil	Tr.	4
5	15	11	7.2	11	14	13	38	27
6	White	White	White	White	White	White	White	Brown
7	12	7	5.4	9	12	9	32	19
8	Brown	Brown	N.v.c.	Sl. bng.	N.v.c.	N.v.c.	Bng.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.0	1.7	1.7	1.8	2.1	2.5	5.1	2.9
11	0.001	0.001	0.004	0.002	0.001	0.002	Nil	0.07
12	0.002	0.006	0.001	0.007	0.005	0.001	0.008	0.02
13	0.01	0.01	Nil	0.01	Nil	Nil	0.01	0.5
14	Nil	Nil	Nil	Nil	Nil	Tr.	0.9	Nil
15	1.2	1.3	1.0	1.7	1.5	2.2	13.2	6.8
16	1.6	0.6	0.5	1.9	3.9	2.1	7.7	11.4
17	Good	Good	Good	Good	Good	Good	—	—

	369	370	371	372	373	374	375	376
1	Clear	Clear	Clear	Clear	Sl. op.	Clear	Clear	Clear
2	V. st. wh.	Sl. bn.	V. st. bn.	V. st. bn.	Sl. bn.	Sl. wh.	Nil	Nil
3	Nil.	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Nil	Tr.	Tr.	Tr.	Nil
5	18	16	22	16.6	28	27	26	27
6	White	White	White	White	White	White	White	White
7	15	12	17	15	23	18	20	20
8	N.v.c.	Bng.	Sl. bng.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.1	2.4	3.6	3.2	4.2	4.4	3.2	3.5
11	0.0006	0.002	0.002	0.0006	0.001	0.0006	0.0006	0.0008
12	0.001	0.001	0.002	0.001	0.002	0.002	0.002	0.001
13	0.01	Nil	Nil	Nil	0.006	Nil	0.01	Nil
14	Nil	Nil	Nil	Tr.	0.8	0.7	Nil	0.4
15	5.5	3.3	4.1	3.2	3.3	4.7	3.8	2.7
16	4.3	2.5	3.7	4.6	8.1	4.8	9.8	8.3
17	Good	—	—	—	Good	Good	Good	Good

	377	378	379	380	381	382	383	384
1	Clear	Clear	Clear	Op.	Clear	Sl. op.	Sl. op.	Sl. op.
2	Sl. bn.	Nil	Sl. bn.	Sl. bn.	Sl. wh.	Sl. wh.	Sl. wh.	Sl. wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Nil	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	29	21	32	42	39	62	60	74
6	White	White	White	White	White	White	White	White
7	24	18	26	35	34	47	47	58
8	N.v.c.	Bng.	N.v.c.	Sl. bn.	Sl. bn.	Ni. ox.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	3.6	2.8	3.3	3.6	3.5	7.5	7.0	9.5
11	0.0008	0.002	Nil	0.003	0.002	0.001	0.001	Nil
12	0.006	0.006	0.002	0.004	0.002	0.006	0.006	0.007
13	Nil	0.02	Nil	0.01	Nil	0.02	0.05	0.05
14	Nil	Nil	Tr.	Nil	Nil	1.1	0.7	0.5
15	2.7	2.5	2.3	4.5	3.5	7.0	7.7	10.5
16	12.8	4.9	8.6	4.5	5.5	14.0	16.9	16.8
17	Good	Good	Good	Good	Good	Pass.	Good	Good

	385	386	387	388	389	390	391	392
1	Clear	Clear	Op.	Op.	Sl. op.	Op.	Clear	Clear
2	Nil	V. Sl.wh.	Sl. bn.	Sl. wh.	Brown	Sl. wh.	Nil	Nil
3	Nil	Nil	Nil	Nil	Earthy	Nil	Nil	Nil
4	Nil	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Nil
5	81	92	459	76	164	127	74	62
6	White	White	White	White	White	White	White	White
7	68	73	403	62	142	105	59	54
8	Sl. bng.	Sl. bk.	Bkg.	Bkg.	Bkg.	Bkg.	Sl. bk.	Sl. bk.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.7	19.8	86.0	12.0	5.3	7.0	7.0	6.3
11	Nil	0.002	0.002	0.001	0.0006	0.001	0.001	Nil
12	0.006	0.006	0.01	0.01	0.009	0.01	0.008	0.006
13	0.02	0.01	0.1	0.04	0.07	0.2	0.04	0.02
14	0.7	Nil	Nil	Nil	Nil	Nil	0.4	Tr.
15	12.4	14.5	190.0	31.0	55.0	41.0	14.5	8.2
16	21.6	21.5			13.0	16.0	18.5	23.8
17	Good	Good	M.W.	Good	V. hard	—	Good	Good

	393	394	395	396	397	398	399	400
1	Clear	Sl. op.	Clear	Sl. op.	Clear	Clear	V. st. op.	V. st. op.
2	Nil	Sl. wh.	Sl. wh.	Sl. wh.	Nil	V. st. bn.	V. st. wh.	V. st. wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	18	19	21	23	20	49	62	46
6	White	White	White	White	White	White	White	White
7	13	16	17	17	17	39	45	40
8	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Tr.	Nil	Nil
10	2.0	1.9	1.8	1.6	1.8	4.4	3.7	3.7
11	0.0006	0.003	0.0006	Nil	0.001	0.003	0.0008	0.003
12	0.001	0.003	0.002	0.001	0.001	0.006	0.002	0.006
13	Nil	Nil	Nil	Nil	Nil	0.03	0.006	0.03
14	Nil	Tr.	Tr.	Nil	Nil	0.6	Nil	0.5
15	2.0	2.2	2.4	2.0	2.9	16.0	13.0	11.4
16	5.0	8.7	8.5	6.2	8.0	16.0	12.5	13.2
17	Good	Good	Good	Good	Good	Good	Good	Good

	401	402	403	404	405	406	407	408
1	Sl. op.	Sl. op.	Sl. op.	Sl. op.	Clear	Clear	Clear	Clear
2	Sl. bn.	Sl. bn.	Sl. gy.	Sl. wh.	Sl. bn.	Nil	Nil	Nil
3	Nil	Nil	Slight	Slight	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Nil	Nil
5	55	72	52	57	78	76	66	50
6	White	White	White	White	White	White	White	White
7	40	57	35	44	60	61	55	39
8	N.v.c.	Sl. bk.	N.v.c.	Sl. bng.	Sl. bng.	Bkg.	Sl. bkg.	Sl. bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	3.9	7.7	3.2	5.3	4.9	4.7	7.5	5.2
11	Nil	0.001	0.0008	0.0008	Nil	0.001	Nil	0.0006
12	0.007	0.005	0.004	0.002	0.006	0.006	0.006	0.005
13	0.04	0.1	Nil	Nil	0.05	0.05	Nil	Nil
14	0.7	Tr.	Nil	Nil	Nil	0.7	0.8	Tr.
15	15.5	17.0	8.0	21.0	23.6	27.5	13.5	11.5
16	14.5	19.0	19.0	17.0	23.4	9.5	18.5	20.5
17	Good	Pass.	Good	Good	Good	Good	Good	Good

	409	410	411	412	413	414	415	416
1	Clear	Clear	Clear	Clear	Clear	Op.	Clear	Clear
2	Nil	Nil	V. sl. wh.	V. sl. wh.	Sl. wh.	Sl. bn.	Sl. bn.	Sl. wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	55	52	58	75	101	100	77	87
6	White	White	White	White	White	Yellow	White	White
7	45	41	47	64	72	80	61	59
8	Sl. bng.	Sl. bk.	Sl. bng.	Sl. bk.	Bng.	Bng.	Bng.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	7.0	3.8	4.0	7.5	11.0	7.5	6.4	12.8
11	0.001	Nil	Nil	0.0008	0.003	0.002	Nil	0.0008
12	0.005	0.003	0.008	0.01	0.008	0.006	0.004	0.004
13	Nil	0.006	0.02	0.04	0.02	0.06	0.02	0.01
14	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	0.7	Tr.
15	11.5	11.5	10.5	19.0	19.0	38.0	45.0	29.0
16	20.5	20.5	16.8	20.0	31.0	14.0		20.0
17	Good	Good	Good	—	Good	Good	Good	Good

	417	418	419	420	421	422	423	424
1	Sl. op.	Clear	Clear	Clear	Clear	Clear	V. st. op.	V. St. op.
2	Sl. bn.	V. st. bn.	Sl. wh.	Nil	V. st.wh.	Nil	V. sl. wh.	Sl. yel.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Nil	Tr.	Nil	Tr.	Tr.
5	62	40	61	50	60	57	53	46
6	White	White	White	White	White	White	White	White
7	47	35	45	41	47	36	47	38
8	N.v.c.	V.st.bkg	V.st.bkg	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.4	1.9	4.9	5.8	6.4	9.3	7.0	2.6
11	0.002	0.0008	0.003	0.0008	Nil	0.0006	0.0008	Nil
12	0.005	0.008	0.008	0.006	0.008	0.006	0.004	0.003
13	0.01	0.02	0.04	0.01	0.03	0.02	0.03	0.02
14	Tr.	Nil	0.3	0.4	Tr.	Nil	Tr.	Nil
15	11.4	9.0	9.5	7.0	10.9	13.5	10.5	7.3
16	19.6	9.5	13.5	15.0	12.7	18.5	13.0	14.5
17	Good	Good	Good	Good	Good	Good	Good	Good

	425	426	427	428	429	430	431	432
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
2	V. st. bn.	V. st. wh.	V. st. bn.	V. sl. wh.	V. sl. wh.	V. sl. bn.	Nil	Slight
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Tr.
5	43	64	26	78	60	45	292	159
6	White	White	White	White	White	White	White	White
7	35	50	22	66	44	35	251	134
8	N.v.c.	Sl. bng.	N.v.c.	Sl. bng.	Sl. bng.	N.v.c.	Bkg.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.8	5.8	2.1	11.0	7.7	2.8	39.0	9.9
11	Nil	0.001	0.0004	0.0008	0.0006	Nil	0.009	0.0008
12	0.004	0.004	0.001	0.006	0.005	0.003	0.009	0.009
13	Nil	0.01	Nil	0.02	0.02	Nil	0.01	0.06
14	Tr.	1.0	Nil	0.7	0.6	Nil	Nil	Nil
15	8.2	10.0	4.0	20.9	13.2	10.9	115.0	49.0
16	15.4	17.3	8.5	13.1	8.6	9.1		18.0
17	Good	Good	Good	Pass.	Good	Pass.	M.W.	Pass.

	433	434	435	436	437	438	439	440
1	Clear	Op.	Clear	Sl. yel.	Op.	Clear	Op.	Clear
2	Nil	Brown	V. sl. wh.	Nil	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Sl. ; bad	Slight	Nil	Slight	Slight
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	123	479	270	951	435	87	665	527
6	White	White	White	White	White	White	White	White
7	101	422	262	913	347	79	626	509
8	N.v.c.	Sl. bk.	Bkg.	Bkg.	Bkg.	Bng.	Bkg.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	15.1	26.8	106.2	554.8	29.2	16.3	117.9	169.3
11	0.0008	0.02	0.07	0.8	0.007	0.001	0.002	0.01
12	0.006	0.009	0.007	0.03	0.009	0.008	0.006	0.01
13	0.02	0.04	0.01	0.3	0.08	0.05	0.02	0.01
14	Nil	Nil	Nil	1.8	Tr.	Tr.	Nil	Nil
15	26.4	97.0	0.0	64.0	107.0	15.0	75.0	16.0
16	18.6	33.0	1.4	18.0	53.0	20.0	40.0	35.0
17	Good	M.W.	M.W.	M.W.	M.W.	Good	M.W.	M.W.

	441	442	443	444	445	446	447	448
1	Sl. op.	Sl. op.	Clear	Clear	Sl. op.	Clear	Clear	Sl. op.
2	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Nil	Sl. bn.
3	Slight	Slight	H_2S	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Tr.
5	461	550	685	512	296	45	35	435
6	White	White	White	White	White	White	White	White
7	445	530	649	440	251	34	29	357
8	Bng.	Bng.	Bng.	N.v.c.	Bng.	Bkg.	Bkg.	Melted
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	179.8	196.2	338.7	35.0	24.5	3.0	2.2	25.1
11	0.001	0.0008	0.005	Nil	Nil	0.0008	0.004	0.001
12	0.01	0.008	0.002	0.006	0.006	0.007	0.01	0.006
13	0.02	0.01	0.01	0.01	0.01	0.04	0.02	0.02
14	Tr.	Tr.	Tr.	Nil	Tr.	1.9	Nil	Tr.
15	0.0	1.5	20.0	140.0	75.0	6.8	2.9	105.0
16	12.3	38.5	38.0	35.0	25.0	7.7	11.2	70.0
17	M.W.	M.W.	M.W.	M.W.	M.W.	Pass.	Pass.	M.W.

	449	450	451	452	453	454	455	456
1	Clear	Op.	Op.	Sl. op.	Sl. op.	Clear	Clear	Clear
2	Nil	Sl. wh.	V. sl. wh.	V. sl. wh.	Sl. bn.	Sl. wh.	Sl. bn.	Sl. wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	58	577	75	59	77	64	62	45
6	White	White	White	White	White	White	White	White
7	43	500	52	41	58	45	47	37
8	Bkg.	N.v.c.	Sl. bk.	N.v.c.	Sl. bk.	Sl. bng.	Bng.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.8	102.2	2.2	3.7	6.4	4.3	5.8	4.2
11	0.001	0.05	0.002	Nil	0.001	0.0008	0.006	0.006
12	0.009	0.008	0.007	0.003	0.008	0.002	0.008	0.001
13	0.01	0.04	0.04	0.01	0.06	Nil	0.02	Nil
14	Tr.	Nil	Tr.	Nil	Nil	Nil	Nil	Tr.
15	—	190.0	21.0	11.5	13.5	23.6	11.5	8.0
16	—	60.0	23.0	14.5	18.5	19.4	18.5	13.0
17	Good	M.W.	Good	Good	Good	Good	Good	Good

	457	458	459	460	461	462	463	464
1	Clear	Clear	Clear	Sl. op.	Sl. op.	Clear	Clear	Sl.op.
2	Nil	Sl. bn.	Nil	Nil	V. st. wh.	Nil	Nil	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Nil	Nil	Tr.	Nil	Nil	Tr.
5	39	63	29	18	42	86	57	39
6	White	White	White	White	White	White	White	White
7	30	43	22	15	35	68	40	33
8	Bng.	Sl. bng.	Bng.	N.v.c.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bk.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	8.1	6.3	4.6	4.3	5.6	7.4	5.1	3.7
11	0.002	0.0008	Nil	0.0008	0.003	0.001	0.002	0.005
12	0.005	0.005	0.003	0.001	0.007	0.004	0.005	0.006
13	0.01	Nil	Nil	Nil	0.04	0.02	0.02	0.02
14	Tr.	Tr.	Nil	Nil	Nil	0.6	1.1	Nil
15	5.0	13.2	3.3	3.2	8.0	26.4	15.5	3.8
16	12.0	14.1	8.1	6.6	9.0	24.6	18.5	15.7
17	Good	Good	Good	Good	Good	Good	—	Good

	465	466	467	468	469	470	471	472
1	Clear	Clear	Sl. op.	Clear	V. st. op.	Sl. op.	Op.	Sl. op.
2	Sl. bn.	Nil	Sl. bn.	V. sl. wh.	Sl. wh.	Brown	Brown	Brown
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Nil	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	54	54	17	25	40	47	45	43
6	White	White	White	White	White	White	Brown	White
7	46	42	13	18	31	42	38	37
8	Bng.	Bng.	N.v.c.	Bng.	N.v.c.	N.v.c.	Sl. bng.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.6	12.1	3.0	2.3	4.4	2.9	3.5	4.2
11	0.0008	0.002	0.001	0.002	0.002	0.0008	0.008	0.001
12	0.009	0.002	0.002	0.01	0.002	0.006	0.006	0.009
13	Nil	0.01	0.01	0.04	Nil	0.08	0.09	0.04
14	Tr.	Tr.	Nil	Nil	Nil	Nil	Nil	Nil
15	10.0	6.5	2.1	4.6	8.0	3.2	4.5	4.0
16	21.0	19.0	3.9	2.2	11.0	19.3	16.5	17.0
17	Good	Good	Good	Pass.	Good	Good	Good	Good

	473	474	475	476	477	478	479	480
1	Clear	Sl. op.	Clear	Clear	Clear	Clear	Sl. op.	Sl. op.
2	Sl. bn.	V. st. wh.	Sl. bn.	Sl. bn.	Sl. wh.	Nil	Sl. wh.	V. st. wh.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Tr.
5	290	63	77	75	46	38	40	44
6	White	White	White	White	White	White	White	White
7	250	41	66	65	38	32	31	36
8	N.v.c.	Sl. bk.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	9.3	5.8	8.7	9.1	3.5	3.0	3.2	3.0
11	0.002	0.003	0.0008	0.0004	0.0006	0.009	0.006	Nil
12	0.004	0.004	0.007	0.003	0.005	0.005	0.004	0.002
13	0.02	Nil	0.02	0.02	Nil	Nil	0.03	Nil
14	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
15	95.0	19.6	18.5	18.5	8.2	6.4	8.2	1.6
16	27.0	20.4	31.5	31.5	19.1	15.4	15.4	22.9
17	M.W.	Good	Good	Good	Good	Good	Good	Good

	481	482	483	484	485	486	487	488
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
2	Nil	Nil	Sl. wh.	Nil	Nil	Nil	Nil	Sl. bk.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Tr.	Nil	Tr.	Nil	Nil	Tr.
5	49	56	58	48	47	46	50	56
6	White	White	White	White	White	White	White	White
7	39	44	48	40	40	43	43	47
8	N.v.c.	N.v.c.	Sl. bn.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Bk. fetid
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.3	4.3	2.8	2.5	2.6	2.3	2.2	8.1
11	0.004	0.0006	Nil	0.001	0.0006	Nil	0.001	0.003
12	0.003	0.002	0.003	0.001	0.001	0.001	0.001	0.008
13	0.01	Nil	Nil	Nil	0.01	Nil	Nil	0.04
14	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
15	4.5	7.0	10.0	9.1	6.8	5.8	7.2	11.5
16	19.0	16.5	18.2	15.4	18.7	20.7	20.8	20.5
17	Good	Good	Good	Good	Good	Good	Good	Good

	489	490	491	492	493	494	495	496
1	V. st. op.	Clear	Clear	Clear	V. st. op.	Clear	Clear	Clear
2	V. st. wh.	V. st. wh.	V. st. wh.	Nil	Sl. yel.	Sl. yel.	V. st. wh.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Nil	Tr.	Tr.	Tr.	Tr.
5	49	35	37	37	46	53	45	35
6	White	White	White	White	White	White	White	White
7	39	25	25	27	39	40	37	24
8	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bk.	Sl. bng.	Sl. bng.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	7.7	3.9	3.9	4.1	4.6	10.5	3.5	2.1
11	0.0006	0.0008	0.001	Nil	0.001	0.001	0.0008	0.001
12	0.005	0.006	0.005	0.004	0.005	0.009	0.002	0.004
13	0.006	0.09	0.08	0.04	0.02	0.04	Nil	0.02
14	0.3	Tr.	Tr.	Tr.	Nil	Tr.	Nil	0.5
15	6.5	5.6	5.6	1.8	2.8	20.0	8.6	5.5
16	11.0	9.4	8.9	11.8	17.2	1.8	16.9	10.5
17	Good	Good	Good	Good	Good	Good	Good	Good

	497	498	499	500	501	502	503	504
1	Sl. op.	Sl. op.	Clear	Sl. op.	Clear	Clear	Clear	Clear
2	Hv. bn.	Sl. bn.	Nil	Slight	Nil	Nil	Nil	Sl. wh.
3	Nil	Sl. stag.	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Nil	Tr.	Nil	Nil	Tr.	Tr.
5	40	39	31	33	91	92	56	56
6	White	White	White	White	White	White	White	White
7	33	35	28	29	72	80	42	50
8	Sl. bk.	Sl. bng.	N.v.c.	N.v.c.	N.v.c.	Bkg.	N.v.c.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	7.2	3.2	3.1	3.2	11.0	8.1	3.5	4.2
11	0.006	Nil	0.0006	0.0006	0.001	0.0006	0.0008	0.001
12	0.004	0.008	0.004	0.007	0.007	0.005	0.005	0.005
13	0.03	0.09	Nil	0.08	0.03	0.02	0.06	0.02
14	Tr.	Nil	Nil	Nil	0.8	0.8	Tr.	Tr.
15	3.1	3.5	0.9	1.0	13.6	16.4	20.0	8.2
16	14.4	15.0	14.1	13.5	10.0	23.6	21.0	20.9
17	Good	—	—	—	Good	Good	Good	Good

	505	506	507	508	509	510	511	512
1	Op.	Sl. op.	Clear	Clear	Clear	Clear	Clear	Clear
2	Sl. bn.	Sl. bn.	Nil	Nil	Nil	Nil	Nil	Nil
3	H_2S.	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Nil	Nil	Nil	Nil	Nil	Nil
5	74	74	68	32	45	47	45	48
6	Brown	White	White	White	White	White	White	White
7	53	65	55	25	38	37	34	42
8	Bkg.	Bkg.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	4.9	7.0	14.7	3.8	8.1	8.0	7.9	9.3
11	0.0008	0.01	0.0008	0.0008	0.0006	0.0006	0.0008	0.0008
12	0.007	0.008	0.001	0.001	0.001	0.001	0.002	0.003
13	0.1	0.05	Nil	Nil	Nil	Nil	Nil	Nil
14	Nil	Tr.	1.4	Tr.	0.9	0.9	0.9	1.1
15	} 27.3	13.2	10.9	3.7	9.5	9.5	11.3	11.0
16	}	19.8	11.8	10.4	16.0	8.0	7.2	9.0
17	H_2S.	Pass.	Pass.	Good	Good	Good	Good	Good

	513	514	515	516	517	518	519	520
1	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Sl. op.
2	Nil	Nil	Nil	Nil	Nil	Sl. bn.	Nil	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Nil	Nil	Nil	Tr.	Nil	Tr.
5	57	53	62	84	37	306	58	70
6	White	White	White	White	White	White	White	White
7	49	44	52	76	30	258	46	62
8	N.v.c.	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Bng.	Bng.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	9.3	10.0	11.6	16.0	6.3	91.1	4.9	13.4
11	0.001	0.001	0.0008	0.0008	0.002	0.007	0.002	0.03
12	0.002	0.001	0.002	0.004	0.002	0.008	0.008	0.006
13	Nil	Nil	Nil	0.02	0.006	0.06	0.02	0.04
14	1.2	1.1	1.2	0.3	0.8	Nil	Nil	Tr.
15	12.7	10.4	11.4	11.4	8.4	} 122.0	9.1	2.4
16	12.3	11.6	11.1	25.6	11.6	}	15.5	12.2
17	Good	Good	Good	Good	Good	M.W.	Good	Pass.

	521	522	523	524	525	526	527	528
1	Sl. op.	Sl. op.	Sl. op.	Clear	Sl. op.	Clear	Sl. op.	Sl. op.
2	Sl. bn.	Sl. bn.	V. st. bn.	V. st.yel.	Sl. bn.	Nil	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Tr.
5	66	64	37	42	39	47	72	35
6	White	White	White	White	White	White	White	White
7	57	55	32	33	33	38	59	27
8	Bng.	Bng.	Sl. bk.	Bng.	Sl. bng.	Bng.	Sl. bk.	Sl. bk.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	14.0	11.2	3.6	8.1	4.0	3.6	8.7	2.9
11	0.02	0.04	0.0006	0.001	Nil	0.003	0.001	0.001
12	0.005	0.004	0.003	0.004	0.003	0.008	0.008	0.003
13	0.02	0.01	0.02	0.04	Nil	0.04	0.08	0.02
14	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Tr.
15	1.8	0.0	1.5	9.0	2.2	6.8	10.9	5.1
16	11.4	13.6	16.5	12.0	16.0	16.8	20.1	12.9
17	Pass.	Pass.	Good	Good	Good	Good	Good	Good

	529	530	531	532	533	534	535	536
1	Clear	Clear	Clear	Clear	Sl. op.	Clear	Sl. op.	Clear
2	V. st. bn.	Sl. bn.	Nil	Sl. bn.	Sl. bn.	Sl. bn.	Sl. wh.	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Nil	Tr.	Tr.	Tr.	Tr.	Tr.
5	58	46	40	36	46	13	14	12
6	White	White	White	White	White	White	White	White
7	45	40	34	29	41	11	12	10
8	Bng.	Bng.	N.v.c.	Bng.	Bng.	N.v.c.	N.v.c.	N.v.c.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	5.1	4.2	2.0	2.8	2.8	2.2	2.3	2.1
11	0.0008	0.001	Nil	0.0008	Nil	0.005	0.002	0.001
12	0.006	0.003	0.001	0.004	0.006	0.005	0.002	0.0008
13	0.01	0.02	Nil	0.01	0.08	0.01	Nil	Nil
14	Tr.	Nil	Nil	Nil	Nil	Nil	Nil	Nil
15	7.3	10.5	6.4	5.8	0.3	2.3	2.0	1.5
16	18.2	11.3	14.1	16.0	4.4	2.4	5.7	1.6
17	Good	Good	Good	Good	Good	Good	Good	Good

	537	538	539	540	541	542	543	544
1	Op.	Clear	Sl. op.	Clear	Op.	Op.	Op.	Clear
2	Brown	Sl. bn.	Sl. bn.	Nil	Brown	Hv. bn.	Sl. wh.	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Stag.	Nil
4	1.4	Tr.	Tr.	Tr.	Tr.	Hv. tr.	Tr.	Nil
5	1507	113	232	50	653	117	116	25
6	Brown	White	White	White	White	White	White	White
7	1335	93	169	42	619	105	105	21
8	Melted	Sl. bk.	Bng.	N.v.c.	Bkg.	N.v.c.	N.v.c.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	1314.0	23.9	128.0	3.0	78.2	27.4	26.8	3.2
11	0.112	0.004	0.0008	0.0008	0.2	0.04	0.04	0.0006
12	0.006	0.008	0.004	0.008	0.01	0.004	0.001	0.006
13	0.4	0.06	0.02	0.07	0.1	Nil	Nil	0.02
14	Nil	Nil	Tr.	Nil	Tr.	Nil	Nil	0.3
15	185.0	23.6	82.0	8.2	34.0	15.5	15.0	7.0
16	25.0	22.4	33.0	19.1	53.0	8.1	7.7	6.5
17	—	Good	M.W.	Good	M.W.	—	—	Good

	545	546	547	548	549	550	551	552
1	Sl. op.	Clear	Clear	Clear	Clear	Sl. op.	Clear	Clear
2	Sl. bn.	Sl. bn.	Sl. wh.	Nil	Nil	Sl. bn.	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Nil	Nil	Tr.	Tr.	Nil
5	46	64	52	50	52	57	34	45
6	White	White	White	White	White	White	White	White
7	42	50	41	41	44	45	28	40
8	Bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	N.v.c.	Sl. bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	4.9	8.1	8.1	7.0	8.7	10.5	2.8	5.1
11	0.004	0.005	0.001	Nil	0.001	Nil	Nil	0.002
12	0.007	0.006	0.01	0.002	0.004	0.008	0.004	0.005
13	0.01	0.02	0.02	Nil	0.01	0.01	0.02	0.01
14	Nil	1.0	0.6	Nil	Nil	Nil	Nil	Tr.
15	6.4	9.0	7.0	2.7	6.8	8.2	3.0	4.2
16	16.6	18.0	11.0	16.4	15.9	13.6	13.0	14.8
17	Good	Good	—	Good	Good	Good	Good	Good

	553	554	555	556	557	558	559	560
1	Clear	Clear	Yellow	Sl. op.	Sl. op.	Op.	Op.	Op.
2	Nil	Nil	Hv. red.	Nil	Sl. wh.	Brown	Brown	Brown
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Nil	Hv. tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	58	45	417	115	90	99	98	100
6	White	White	White	Brown	White	White	White	White
7	45	38	390	107	82	94	88	92
8	Sl. bng.	N.v.c.	Sl. bn.	N.v.c.	Sl. bn.	N.v.c.	N.v.c.	Sl. bn.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	6.5	5.8	26.8	22.1	22.7	21.6	22.1	22.1
11	0.0008	0.001	0.1	0.01	0.01	0.01	0.01	0.02
12	0.007	0.009	0.008	0.001	0.004	0.001	0.001	0.002
13	Nil	0.006	0.06	Nil	0.02	0.02	0.02	0.01
14	0.6	Tr.	Nil	Nil	Nil	Nil	Nil	Nil
15	9.5	5.4	51.0	5.1	1.8	2.0	3.0	3.9
16	15.1	18.1	31.0	8.5	10.0	10.3	7.0	5.6
17	Good	Good	—	Good	Good	Good	Good	Good

	561	562	563	564	565	566	567	568
1	Sl. op.	Clear	Clear	Clear	Sl. yel.	Clear	Clear	Clear
2	Nil	Sl. wh.	Sl. wh.	Nil	Sl. bn.	Nil	V. st. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Tr.	Tr.	Nil	Tr.	Nil	Tr.	Nil
5	100	58	281	104	260	104	40	43
6	White	White	White	White	Brown	White	White	White
7	93	44	214	92	212	92	35	37
8	N.v.c.	Bkg.	Bkg.	Sl. bng.	Sl. bng.	Sl. bk.	Bng.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	21.6	5.8	59.5	14.0	43.8	23.5	5.1	2.3
11	0.01	0.001	0.004	0.001	0.001	0.001	0.002	Nil
12	0.006	0.004	0.01	0.008	0.007	0.005	0.006	0.004
13	0.01	0.02	0.1	0.07	0.08	0.04	0.04	0.03
14	Nil	Tr.	Nil	0.3	Nil	0.9	0.5	Nil
15	4.0	27.3	73.0	24.5	92.0	18.0	5.3	7.7
16	7.0	27.3	47.0	27.5	38.0	24.0	7.4	11.8
17	Good	Good	M.W.	Good	Hard	—	Good	Good

	569	570	571	572	573	574	575	576
1	Clear	Op.	Clear	Clear	Clear	Clear	Sl. op.	Clear
2	Nil	Hv. bn.	V. st. bn.	Sl. bn.	Sl. bn.	Sl. wh.	V. st. bn.	V. st. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Hv. tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	236	45	21	86	41	39	41	64
6	White	Brown	Brown	Brown	White	White	White	White
7	196	37	18	79	35	32	34	49
8	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Sl. bng.	Sl. bng.	N.v.c.	Bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.1	2.8	2.2	17.9	3.9	3.7	6.4	11.6
11	0.0008	0.0008	0.0006	0.002	0.0008	0.001	0.001	0.003
12	0.01	0.006	0.001	0.001	0.006	0.006	0.007	0.005
13	0.04	0.02	Nil	0.04	0.02	0.01	0.05	0.02
14	Nil	Nil	Tr.	Nil	0.6	0.8	0.7	0.9
15	72.8	9.5	2.0	14.5	5.1	5.3	9.6	9.5
16	24.7	11.4	4.8	16.5	9.4	9.2	12.2	11.0
17	Hd.	—	Good	Good	Good	Good	Good	Good

	577	578	579	580	581	582	583	584
1	Sl. op.	Sl. op.	Clear	Sl. op.	Clear	Clear	Sl. op.	Clear
2	Sl. bn.	Sl. bn.	V. st. bn.	V. st. wh.	V. st. yel.	V.st. wh.	Brown	Nil
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Nil	Hv. tr.	Nil
5	61	21	34	71	66	18	27	29
6	White	White	White	White	White	Nil	Nil	Nil
7	51	18	25	54	51	13	22	23
8	Bng.	Sl. bng.	N.v.c.	Bng.	Bng.	Sl. bng.	Bng.	V.st.bng.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	13.4	5.1	2.8	20.4	8.7	2.6	7.2	3.9
11	0.001	0.0008	0.002	0.0008	Nil	0.004	0.001	Nil
12	0.006	0.01	0.007	0.006	0.006	0.004	0.009	0.003
13	0.04	0.08	Nil	0.04	0.01	0.02	0.05	0.01
14	Tr.	Nil	0.3	Nil	0.5	Tr.	0.3	Tr.
15	8.6	3.3	4.4	9.0	13.5	3.0	—	4.5
16	16.4	7.6	7.9	23.0	15.5	4.3	—	9.0
17	Good	—	Good	Good	Good	Good	—	Good

	585	586	587	588	589	590	591	592
1	Clear	Sl. op.	Sl. op.	Sl. op.	Clear	Op.	Op.	Op.
2	V. st. bn.	V. st. wh.	Sl. bn.	Sl. wh.	Nil	Sl. bn.	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Tr.	Tr.
5	37	48	101	33	22	66	56	64
6	Nil	White	White	White	White	Brown	Brown	Brown
7	30	37	70	26	14	47	40	47
8	Bng.	Sl. bk.	Bng.	N.v.c.	Sl. bk.	Bkg.	Bkg.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Tr.	Nil	Nil
10	7.0	6.5	12.8	3.2	2.4	3.2	3.2	3.8
11	0.001	0.003	0.001	0.004	0.001	0.1	0.02	0.06
12	0.008	0.008	0.006	0.004	0.006	0.4	0.02	0.04
13	0.02	0.04	0.03	0.02	0.01	0.02	0.2	0.4
14	0.8	0.6	0.3	Tr.	Tr.	Nil	Nil	Nil
15	—	9.5	33.0	8.0	4.0	13.6	15.5	16.5
16	—	10.5	23.0	4.3	2.4	16.4	11.8	11.7
17	Good	Good	Good	Good	Good	—	—	—

	593	594	595	596	597	598	599	600
1	Op.	Op.	Op.	Op.	Sl. yel.	Pink	Sl. yel.	Sl. op.
2	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Sl. bn.	Hv. bn.	Sl. bn.	Sl. op.
3	Nil	Nil	Nil	Nil	Nil	Sl. ; bad	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Hv. tr.	Tr.	Tr.
5	38	50	54	57	123	50	20	16
6	White	White	White	White	White	White	White	White
7	28	43	42	41	101	47	15	12
8	Bkg.	Bkg.	Bkg.	Bkg.	Bkg.	Bkg.	Bng.	Bng.
9	Nil	Nil	Nil	Nil	Tr.	Nil	Nil	Nil
10	2.3	2.8	2.9	3.7	13.4	5.2	3.6	3.0
11	0.01	0.01	0.01	0.03	0.002	0.01	0.006	0.003
12	0.02	0.02	0.01	0.02	0.03	0.01	0.01	0.01
13	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.2
14	Nil	Nil	Nil	Nil	Tr.	Tr.	Nil	Nil
15	10.9	—	12.4	15.0	37.0	6.4	2.5	2.1
16	10.1	—	17.6	17.0	16.0	24.6	3.7	2.2
17	—	—	—	—	—	—	—	—

	601	602	603	604	605	606	607	608
1	Op.	Op.	Sl. yel.	Op. bn.	Sl. op.	Clear	Sl. op.	Sl. bn.
2	Sl. bn.	Sl. bn.	Tr.	Hv. bn.	Brown	Nil	Brown	Nil
3	Nil	Nil	Nil	Nil	Slight	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Hv. tr.	Hv. tr.	Tr.	Tr.	Tr.
5	23	74	65	56	85	68	75	73
6	Brown	White	White	Brown	White	White	White	White
7	16	59	59	46	65	52	57	52
8	Bkg.	Bkg.	Bkg.	Bkg.	Sl. bkg.	Brown	Brown	Brown
9	Nil	Nil	Nil	Nil	Nil	Nil	Tr.	Tr.
10	2.8	33.3	35.0	3.9	5.3	5.8	4.9	4.4
11	0.004	0.007	0.0008	0.016	0.01	0.0008	0.005	0.002
12	0.02	0.01	0.006	0.06	0.02	0.008	0.02	0.007
13	0.3	0.2	0.06	0.7	0.2	0.05	0.2	0.08
14	Nil	Tr.	Tr.	Nil	Nil	Tr.	Nil	Nil
15	2.1	5.9	6.8	3.2	28.2	16.0	19.0	18.0
16	2.3	9.6	7.7	5.0	19.8	21.0	23.0	22.0
17	—	—	—	—	—	—	—	—

	609	610	611	612	613	614	615	616
1	Clear	Op.	Op.	V. st. op.	Clear	Clear	Sl. op.	Sl. op.
2	Nil	Sl. bn.	Sl. bn.	Sl. bn.	V. st. wh.	Nil	Sl. bn.	Sl. bn.
3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
4	Nil	Tr.	Tr.	Tr.	Tr.	Nil	Tr.	Tr.
5	78	81	84	25	29	24	23	20
6	White	White	White	White	White	White	White	White
7	59	59	68	17	20	20	18	16
8	Brown	Brown	Brown	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.	Sl. bng.
9	Tr.	Tr.	Tr.	Nil	Nil	Nil	Nil	Nil
10	4.9	5.3	5.1	3.6	3.2	2.4	2.5	2.5
11	0.001	0.004	0.005	0.002	0.001	0.001	0.001	0.0008
12	0.008	0.03	0.02	0.02	0.008	0.009	0.007	0.006
13	0.2	0.4	0.2	0.1	0.06	0.09	0.05	0.06
14	Nil	Nil	Tr.	Nil	Nil	Nil	Nil	Nil
15	17.0	18.0	20.5	3.1	3.1	1.9	1.7	1.8
16	24.0	22.0	23.5	10.5	10.5	11.3	9.7	9.1
17	—	—	—	—	—	—	—	—

	617	618	619	620	621	622	623	624
1	Clear	V. st. op.	Sl. op.	Op. ; yel.	Op.	Op.	Op.	Op.
2	Sl. wh.	Sl. yel.	Sl. bn.	Sl. bn.	V. st. bn.	V. st. bn.	V. st. bn.	V. st. bn.
3	Nil	Nil	Nil	Sl. stag.	Nil	Nil	Nil	Nil
4	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.	Tr.
5	20	29	30	77	138	118	298	343
6	White	White	White	Yellow	White	Brown	Brown	Brown
7	14	18	23	52	122	108	248	309
8	Sl. bng.	Sl. bk.	Sl. bkg.	Bk. fetid	Bkg.	Bkg.	Bkg.	Bkg.
9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	2.2	2.8	2.8	6.0	92.0	74.7	230.0	277.0
11	0.003	0.001	0.003	0.007	0.07	1.5	3.0	1.5
12	0.009	0.008	0.01	0.03	0.03	0.05	0.05	0.07
13	0.07	0.06	0.1	0.2	0.2	0.6	0.4	0.4
14	Nil	Nil	Nil	Nil	Tr.	—	Nil	Nil
15	2.5	2.7	2.0	21.0	11.4	—	—	—
16	4.3	7.8	9.2	16.0	7.7	—	—	—
17	—	—	—	—	—	—	—	—

TABLE II.—MINERAL CONSTITUENTS OF CERTAIN WATERS (In parts per 100,000).

No. in List	39	71	152a	184	189	193	262	265	322	372	373	376
SiO_2	0.84	1.12	3.48	4.06	—	4.02	0.88	1.24	1.30	1.1	0.9	0.63
$Fe_2O_3+Al_2O_3$	0.28	Trace	0.42*c*	Trace	—	0.32	0.4	Trace	Trace	Nil	0.16	0.12
CaO	10.06	2.74	14.48	68.57	78.2	12.22	55.3	22.84	40.01	3.24	7.86	7.71
MgO	4.91	1.55	9.02	8.82	21.7	5.48	16.3	27.59	36.31	2.31	1.19	1.18
Na_2O	2.48	1.84	} 200.41 {	7.4	21.4	3.33	12.9	186.13	27.26	} 5.83	2.46	2.89
K_2O	0.17	0.58		0.96	—	7.15	Trace	—	5.56			
SO_3	2.78	1.15	59.11	109.36	130.9	7.79	86.4	216.22	136.89	1.37	1.76	1.87
CO_2	10.20	—	—	—	—	12.58	—	—	—	—	4.92	—
Cl	3.54	1.4	—	1.76	1.8	5.66	—	84.96	10.26	1.98	2.54	2.12
—	—	—	—	—	—	—	20.4*e*	Trace *f*	—	—	3.28*f*	1.69*f*
Totals	35.26	10.38	286.92	200.93	254.0	58.55	192.58	538.98*g*	257.59	15.83	25.07	(*i*)

No. in List	393	435	499	537	556	557	561	625	626	627	628
SiO_2	0.98	1.46	—	—	1.22	1.3	1.25	0.8*j*	Trace *j*	1.2 *j*	Trace *j*
$Fe_2O_3+Al_2O_3$	Trace	Trace	—	0.96	0.88	0.42	0.25	0.3	Trace	Trace	Trace
CaO	7.77	1.22	11.0	96.29	7.44	5.32	6.40	73.2	87.0	60.0	53.0
MgO	0.55	0.51	—	10.93	2.23	1.78	2.15	18.7	18.1	13.3	10.1
Na_2O	} 0.68 {	107.73	—	} 526.56 {	33.43	33.96	36.72	285.0	243.9	182.0	171.8
K_2O		25.32	—		4.72	0.12	0.15	—	—	—	—
SO_3	—	65.52	1.71	3.03	38.99	30.34	36.59	214.0	216.7	108.3	116.6
CO_2	—	—	8.63	—	—	—	—	—	—	—	—
Cl	1.21	64.42	1.88	797.33	13.44	13.80	13.08	262.5	269.4	216.7	173.7
—	—	—	—	1.62*b*	—	—	—	Nil *k*	0.1*k*	Sl. tr. *k*	V. sl. odour *k*
Totals	11.19	266.18	23.22	1436.72	102.35	87.04	96.59	854.5	835.2	581.5	525.2

b. Insoluble matter.
c. Mainly iron.
e. NaCl.
f. N_2O_5.
g. Total solids determined as 540.256.
i. Total solids determined as 24.1.
j. Matter insoluble in HCl.
k. Sulphuretted hydrogen.

TABLE III

	629	630	631	632	633	634	635	636	637	638 *d*
Total solid matter	—	—	—	—	—	3.8	6.7	—	13.7*a*	11.72
Do. do. dissolved ...	18.26	83.64	83.52	9.44	6.48	—	—	12.250	—	—
Ammonia (free or saline) ...	Nil	0.090	Nil	0.002	0.001	0.003	0.000	0.003	—	—
Do., organic or albuminoid	—	—	—	—	—	0.008	0.004	—	—	—
Nitrogen in nitrates ...	—	—	—	—	—	Nil	Nil	0.390	—	—
do. in do. and nitrites	0.169	3.069	5.322	0.173	0.144	—	—	—	0.609	0.407
do. organic *c* ...	0.004	0.069	0.056	0.009	0.009	—	—	—	0.024	0.012
do. total combined ...	0.173	3.212	5.378	0.184	0.154	—	—	—	—	—
Previous sewage or animal contamination *b* ...	1,370	31,110	52,900	1,420	1,130	—	—	—	—	—
Carbon, organic	0.015	0.253	0.012	0.31	0.37	—	—	—	0.068	0.020
Chlorine (in chlorides) ...	1.60	8.38	8.20	1.20	1.20	0.9	1.0	1.300	1.55	1.2
Total oxygen absorption (4 hrs., 27°C., 80° F.) ...	—	—	—	—	—	0.25	0.21	—	—	—
Hardness in degrees Clark — temporary ...	3.36	18.83	7.91	0.21	0	—	—	1.62	6.2	1.1*e*
Hardness in degrees Clark — permanent ...	4.62	10.08	12.11	3.71	2.45	—	—	2.28	3.8	3.9*e*
Hardness in degrees Clark — total ...	7.98	28.91	20.02	3.92	2.45	0.7	2.2	3.90	10.0	5.0*e*
Turbidity	Clear	Clear	Clear	Clear	—	Nil	Nil	Turbid	Clear	Clear
Tintometer colour in 2-ft. tube *f* — red ...	—	—	—	—	—	1.3	1.0	—	—	—
Tintometer colour in 2-ft. tube *f* — yellow ...	—	—	—	—	—	4.3	4.4	—	—	—
Tintometer colour in 2-ft. tube *f* — blue ...	—	—	—	—	—	0.6	0.2	—	—	—
Remarks	Palatable				—	—*g*	—*g*	—	—	—

(For footnotes see p. 179).

TABLE III *continued.*

	639	640	645	646	647	648	649	650	651	652
Total solid matter	125.0	135.6	60.0	60.0	179.0	119.0	43.0	31.0	25.0	48.0
Ammonia (free or saline) ...	0.018	0.021	0.126	0.067	0.007	0.016	0.0044	0.005	0.001	0.006
Do., organic or albuminoid	0.006	0.008	0.040	0.030	0.016	0.023	0.005	0.018	0.0034	0.0109
Nitrogen in nitrates ...	0.337	0.409	Trace	Trace	Trace	Trace	0.20	Trace	0.30	Trace
Chlorine in chlorides ...	29.0	37.5	2.70	2.50	4.90	7.90	1.50	1.60	1.20	4.20
Total oxygen absorption (4hrs., 27°C., 80° F.) ...	0.038*h*	0.027*h*	0.329	0.300	0.273	0.314	0.030	0.161	0.044	0.244
Phosphoric acid	—	—	Heavy	Trace	Trace	Trace	Trace	Trace	Trace	Trace
Hardness in degrees Clark { temporary ...	—	9.5	7.64	8.04	14.40	16.10	11.08	7.40	8.40	13.98
Hardness in degrees Clark { permanent ...	—	32.0	17.58	16.96	54.20	31.00	8.60	4.60	4.00	5.50
Hardness in degrees Clark { total ...	—	41.5	25.22	25.00	68.60	47.10	19.68	12.00	12.40	19.48
Turbidity	Clear Bright	Clear some suspended matter	A little suspended matter				Clear *j*	V. turbid	w. earthy	matter
			Brownish-yellow		Yellowish-green		—	—	—	—
Colour in 2-ft.tube ...	—	—								

NOTES TO TABLE III:—*a*, Lime 4.96, Magnesia, 0.72, Sulphuric anhydride 1.26. *b*. These figures denote the equivalent number of parts of 'Standard Sewage' present in 100,000 of the sample analysed, calculated on the basis of combined inorganic nitrogen content (nitrates, nitrites, ammonia) remaining after deduction of a fixed allowance (0.032) for inorganic nitrogen of rain-water; the remainder after these deductions being regarded as due to decomposition of originally organic nitrogen, and hence as a measure of past sewage or animal contamination. The Standard Sewage contains 10 parts per 100,000 of total combined nitrogen. Hence these figures after division by 10,000 and addition of 0.032 should give the combined inorganic nitrogen per 100,000 parts of sample. Water, even from deep wells and deep-seated springs, may be considered suspect or dangerous if the figure for Previous Sewage or Animal Contamination exceeds 10,000 (Rivers Pollution (1868) Commission, Sixth Report, 1874, pp. 13, 14, 17). *c* Regarded as some indication of present pollution (*ibid.*, p. 13). *d* Probably in parts per 100,000, but not stated. *e* Probably in degrees Clark, but not stated. *f* Equality of red and yellow denotes Orange, of yellow and blue denotes Green, of all three colours denotes Grey. *g* Alkalinity (calculated as $CaCO_3$) of No. 634, 0.3; of No. 635, 2.8. *h* Duration of absorption not stated.

TABLE IV.

639, 640. Old Hill Mines.

No. of bacteria per c.c.:	639	640
Gelatin at 22°C., 2 days	22	7
,, ,, ,, 4 ,, ...	28	15
Agar ,, 37°C., 2 ,, ...	0	3
Bacillus coli present in	100 c.c.	100 c.c.
Milk a. ... ... reaction in	50 c.c.	—
B. enteritidis sporogenes	Absent	Absent
Streptococci	Absent	Absent

641–644. Charford boring.

	641	642	643	644
Lime	5.71*a*	5.43	6.87	—
Magnesia	5.35*b*	4.31	4.63	4.41
Chlorine	1.2*c*	1.30	1.95	1.3
Sulphuric acid	0.8*d*	2.44	1.69	—
Nitric acid	—	1.03	Nil	—
Ammonia	0.3*e*	—	—	—
Organic nitrogen	—	—	0.008	0.005
,, carbon...	—	—	0.021	0.012
Totals	13.36	14.51	15.169	5.727
Total solid residue	—	—	26.97	23.80
Hardness { temporary ...	—	0.7	8.1	9.52
Hardness { permanent ...	—	7.0	7.2	3.71
Hardness { total ...	about 20	7.7	15.3	13.23

653, 654. Malvern. 655–657. Tenbury.

f	653	654	655*j*	656	657
$CaCO_3$	0.6157	1.464	2.97	—	—
$MgCO_3$	0.5873	2.120	—	—	—
Na_2CO_3	0.4063	1.333	—	—	—
Fe_2CO_3	0.0473	0.311	—	—	6.98*l*
$CaSO_4$	0.2173	2.367	—	—	—
$MgSO_4$	—	—	1.14	—	2.24
Na_2SO_4	0.6260	0.138	—	—	—
$CaCl_2$	—	—	402.51	341.7	658.70
$MgCl_2$	0.2068	—	10.97	43.4	59.72
NaCl	1.2525	1.351	709.37	1024.0	1332.17
Potash	Trace *g*	—	Trace	—	55.18 *m*
Alumina	—	Traces	—	—	
Silica	0.2938	0.275	1.14		6.48
Iodine	Trace *g*	—	0.15 *k*	Trace	Distinct
Bromine	—	—	0.09 *k*	4.8	traces
Totals	4.2530 *h*	9.359 *i*	1128.34 *k*	1413.9	2121.47

a. Amount in 10.6 parts of $CaCO_3$. *b*. Amount in 7.3 parts of $MgCO_3$, 1.0 of $MgSO_4$, 1.7 of $MgCl_2$. *c*. Amount in 1.7 parts of $MgCl_2$. *d*. Amount in 1.0 parts of $MgSO_4$. *e*. Free 0.2, albuminoid 0.1. *f*. Constituents represented by their modern formulae. *g*. Potassium iodide. *h*. Equal to 2.9772 grains per gallon. *i*. Total given in original as 9.373; the mean of two other determinations of Total Residue was 9.155. This sample showed traces of organic matter. *j*. The first five items are given in the original as 'Lime with C.' 'Magnesia with S.,' 'Lime with M.,' etc., the unexplained C, S, M presumably denoting Carbonate, Sulphate, Muriate (chloride). *k*. The actual amounts of Iodine and Bromine were respectively 0.013 and 0.008 grains per imperial pint. This sample also contained 8.34 cub. in. of Nitrogen, and 34.3 of free CO_2 per 100,000 parts. *l*. Iron protoxide. *m*. Potassium Chloride.

658. Stourbridge. 659. Hampton Spa (Great and Little Hampton).

	658 *n*	659
Carbonate of lime	21.75	—
,, ,, magnesia ...	—	2.04
Sulphate of lime	0.67	53.88
,, ,, magnesia... ...	2.38	54.84
,, ,, soda	—	316.2
Chloride of magnesium ...	—	11.16
,, ,, sodium	2.51 *o*	384.0
Organic matter	2.95	1.2
Loss	1.10	—
Totals... ...	31.36	823.32 *p*

660, 664a. Percentage of Salts in Stoke Prior dairy salt (660) and in Droitwich brine (664a, deduced from 664 below).

	660	664a
Sodium chloride ...	98.29	96.48
Magnesium chloride ...	—	0.07
Calcium sulphate ...	0.87	1.63
Sodium sulphate ...	0.74	1.82
Magnesium sulphate ...	0.06	—
Moisture	0.04	—
Totals ...	100.00 per cent.	100.00 per cent.

661, 662. Brine at Stoke Prior. 663–668. Brine at Droitwich.

	661	662	663	664 *q*
NaCl	25563	25492	22452	32117.4
$MgCl_2$	5	—	—	25.1
$CaSO_4$	437	261	387	541.7
Na_2SO_4	—	594	390	605.7
$MgSO_4$	23	—	—	—
$MgCO_3$	—	34	34	—
$CaCO_3$	10	—	—	—
Totals ...	26038	26381	23263	33289.9

n. Hardness, 17.2°. *o*. Sodium and alkali chlorides. *p*. In addition were found a trace of oxide of iron, and 28.2 cubic inches of carbonic acid gas. The original analysis was expressed as contents of a pint, wine measure (equal almost exactly to five-sixths of the imperial pint), in which the total saline contents amounted to 60.04 grains. *q*. Original analysis expressed in grains per pint, each pint containing 16 (fluid) ounces, instead of the usual 20, and thus being equal to one-tenth of an imperial gallon.

663–668. Brine at Droitwich.

	665	666	667	668*v*
NaCl	30728.3	27703.7	25907.0	30738.8
$MgCl_2$	144.6	—	3.0	500.7
$CaSO_4$	431.6	438.9	108.5	183.3
Na_2SO_4	456.4	441.6	408.0	1243.0
Na_2CO_3	—	164.5	—	2.1 *t*
$MgCO_3$	—	47.8	—	—
Sodium iodide ...	Trace	—	0.2	—
Magnesium bromide	Trace	Trace	—	26.4 *s*
Alumina sulphate ...	—	—	17.1	54.5
Soda silicate ...	1.9	—	—	—
—	—	—	—	3.0 *u*
Totals ...	31762.8 *r*	28796.5	26443.8	32751.8

669—671. Saltwells Spa.

	669	670	671
Sodium chloride	906.22	828	1397.9
Calcium ,, ...	555.30	533	353.9
Magnesium ,, ...	165.17	249	113.0
Aluminium ,, ...	66.0		—
Iron ,, ...	—	45	—
Calcium sulphate	1.22	—	—
,, carbonate	3.6	about	20.4
Magnesium ,, ...	19.06	8*y*	7.4
Iron ,, ...	10.18*w*	15	—
Sodium nitrate	—	—	70.0
Silica	0.34	1	1.4*aa*
Totals (solids) ...	1727.09	1679	1964.0
Carbonic acid (cub. in.)	9.67	41*z*	—
Sulphuretted hydrogen (do.) ...	8.98		—
Nitrogen (do.)	12.17	20	—

r. With trace of FeO. *s*. Sodium bromide. *t*. Lime bicarbonate, $Ca(HCO_3)_2$. *u*. Iron bicarbonate 1.2, silica 1.4, ammonium chloride 0.4, and trace of potassium chloride. *v*. Specific gravity of this brine at 15°C was 1.2129. *w*. Subcarbonate of black oxide of iron [? $FeCO_3$] 5.76, plus subcarbonate of alumina [$Al_2(CO_3)_2$] 3.68 and of manganese [$MnCO_3$] 0.74. *x*. Original analysis of No. 670, and presumably of No. 669, is expressed in grains and cub. in. per wine gallon (see p. 181 footnote *p*.). Comparing these two analyses, the analyst remarks that the proportions of ingredients differ at different times, and that in this case the difference is very remarkable in relation to the oxide of iron. *y*. Earthy carbonates. *z*. The sulphuretted hydrogen in small proportion of this amount. *aa*. Includes oxide of iron.

LIST OF THE ANALYSES.

The following List shows the localities of all the analyses tabulated in this volume, together with any other information that could not conveniently be inserted in the Tables.

Like the details of water-supply in preceding pages, the standard analyses (**Nos. 1–589**) of water from wells, springs and borings—by far the most numerous—are arranged below in alphabetical order—of parishes, towns, or water undertakings—so that cross-reference from details to analyses is easy, and in general has not otherwise been provided for. The remaining analyses—those of river waters (**Nos. 590–624**), and those collected from other publications (**Nos. 625–671**)— are numbered consecutively after the others in the following list ; but as they unavoidably fall outside the arrangement by parishes, reference to each has as far as possible been inserted under the proper parish or other heading in the earlier, alphabetical, part of the list (Nos. 1–589).

At the end of each reference to the analyses of Table I are given two groups of figures. The first of these is the *Date* of the analysis (day, month and year) ; the second is the *Report Number*, if any, of the County Analyst (see p. 150).

In a few cases, owing to vague localization, the analyses may not be entered under their correct parish. In descriptions of localities the depths given for a well invariably refer to the total depth of the well. The geological formations in which the wells, etc., have been sunk have been determined by Mr. Richardson and are indicated in parenthesis, the following abbreviations being used for formations :—

S.D.	Superficial Deposits.	U.M.S.	Upper Mottled Sandstone.
L.L.	Lower Lias.	P.B.	Pebble Beds.
K.M.	Keuper Marl.	L.M.S.	Lower Mottled Sandstone.
L.K.S.	Lower Keuper Sandstone.	C.M.	Coal Measures.
		O.R.S.	Old Red Sandstone.

ANALYSES IN TABLES I AND II

Abberley

1. Apostles Oak, near Abberley Hall. Spring from (Aymestry) limestone (Silurian). (8.ix.05 ; 2137).
2. Abberley Hall supply. Spring, about a mile away. (6.viii.13 ; 5136).
3. The same. (27.i.16 ; 6100).
4. The Elms, Abberley. Well, 61 ft. (C.M.). (27.iv.14 ; 5396).
5. Cottages near School, Abberley. Well (Ditto). (31.x.14 ; 5734).
6. Abberley village. Well. (Ditto). (31 x 21 ; 7435).

Abberton

7. Spring in ' The Parks ' (meadow)—mineral water. (Off L.L.). (20.v.14 ; 5446).
8. New cottages. Well, 80 ft. (K.M.). (30.v.14 ; 5454).
9. Village Well, 90 ft. (11.vi.14 ; 5479).
10. The same. (21.ix.14 ; 5699).
11. Manor Farm. Well, 80 ft. Red (Keuper) marl over (Arden) sandstone. (1.x.14 ; 5703).

Alfrick

12. Alfrick School. Well (K.M. ? to L.K.S.). (4.vii.03 ; 1156).
13. Coppice End. Well, 30 ft. (Ditto). 12.iv.04 ; 1458).
14. Patches Farm. Well, 65 ft. ' Sand ' (L.K.S.). (1.ii.08 ; 2953).
15. Vicarage. New well at 31 ft. depth. (K.M.). (7.v.13 ; 5016).
16. The same, at 41 ft. depth. (K.M.). (3.xii.13 ; 5223).
17. Cherry Green. Well. (May Hill Sandstone—Silurian). (6.iii.20 ; 6988).

Alvechurch

(Wells in Keuper Marl, with or without a capping of gravel and sand, S.D.) :—

18. The Moat House, Radford Road. Well, 95 ft. (23.iv.12 ; 4692).
19. Snake Lane. Well, 30 ft. (28.vii.14 ; 5584).
20. Tan-yard, Alvechurch. Well, 30 ft. (28.vii.14 ; 5585).
21. Birmingham Road. Well, 30 ft. (28.vii.14 ; 5588).
22. Red Lion Street, Alvechurch. Well, 30 ft. (25.viii.14 ; 5634).
23. Rosemary Cottages, Reservoir Road. Well, 30 ft. (10.xii.17 ; 6468).
24. Aqueduct Lane. Well, 40 ft. (24.i.19 ; 6597).
25. Scarefield. Well, 35 ft. (11.ix.19 ; 6800).

Areley Kings

26. Waldwin Villas. New deep well. Sandstone (U.M.S.). (4.vii.03 ; 1157).
27. Astley Road. Well, 90 ft. (U.M.S.). (17.i.06 ; 2266).
28. The same. (23.viii.07 ; 2799).
29. White House Farm. Well. (U.M.S.). (25.ii.10 ; 3938).
30. The same. (14.iii.11 ; 4329).
31. Rectory. Well, 89 ft. (U.M.S.). (3.vi.21 ; 7335).
32. Spring in Botany Bay (from Halesowen Sandstone—C.M.). (1.xii.19 ; 6843).
33. Areley Common. Well, 95 ft. (U.M.S.). (23.viii.07 ; 2801).
34. ,, ,, ,, 103 ft. (U.M.S.). (23.viii.07 ; 2806).
35. Dog Inn, Dunley. Well (L.K.S., Basement Beds). (16.iv.03 ; 1083).

Astley

36. Weatherlane. Well, 50 ft. (L.K.S.). (27.x.02 ; 874).
37. Astley Hall. Well, 113 ft. (Ditto). (10.iii.03 ; 1030).
38. The same. (25.xi.08 ; 3288).
39. The same. (For a mineral analysis see Table II). (27.vi.13 ; 5088).
40. The Foot. Well, 60 ft. (Ditto). (22.viii.03 ; 1243).
41. Spring, near Astley Hall : 8 to 9 gallons per minute (from L.K.S.). (20.viii.13 ; 5146).
42. The same. (27.viii.15 ; 6018).
43. Spring supplying Yarhampton House Farm from limestone (Ludlow). (14.iv.15 ; 5916).
44. Spring supplying Wordley Farm (from O.R.S.). (30.viii.16 ; 6211).

Bayton

45. Supply to part of village. Spring on Collier's Hill Farm, Church Hill (from Trappoid Breccia resting on Old Hill Marls, C.M.). (11.vii.13 ; 5103).

Bellbroughton

46. Horse Shoe Inn. Well (L.K.S.). (3.ix.03 ; 1258).
47. Police Station. Well. (Ditto). (3.ix.03 ;1262).
48. Pool House Farm, south of Bellbroughton. Well, 50 ft. (K.M.). (8.iii.05 ; 1876).
49. Hill Farm, Bellbroughton. Well, 180 ft., gravel and sandstone. (S.D. and ? L.K.S.). (29.xi.06 ; 2554).
50. Brookfield Farm. Well, 60 ft., red sandstone. (L.K.S.). (4.xi.09 ; 3840).
51. Giles House Farm, near Bellbroughton. Well, 70 ft. (Ditto). (27.ix. 10 ; 4161).
52. Fairfield. Well, 18 ft., red sandstone. (Ditto). 15.vii.13 ; 5108).

Bentley Pauncefoot

53. Spring in field near Norgrove Court (from ? gravel on K.M.). (13.vi.21 ; 7342).
54. The same. (6.ix.23 ; 7888).

Beoley

55. The Vicarage. Well, 100 ft., marl. (K.M.). (20.v.12 ; 4712).
56. Holt Hill. Well (new), 36 ft., marl. (Ditto). (16.xii.21 ; 7459).
57. Brockhill. Well (new), 126 ft., marl. (Ditto). (16.xii.21 ; 7460).
58. St. Leonards Grange. Well (artesian), 300 ft., marl and sandstone. (K.M. and ? Arden Sandstone). (31.vii.22 ; 7601).
59. New houses, Beoley. Well (new), 27 ft. ' Sand.' (S.D.). (3.xi.22 ; 7688).

Besford

60. Church Farm. Well catching spring from sand and gravel (S.D. on L.L. clay) from which water is piped to farm. (21.iii.03 ; 1051).
61. Stantons. Well, 10 ft., sand and gravel. (S.D. on L.L. clay). (1.v. 09 ; 3629).
62. Besford Court. Well, 16 ft. (? Ditto). (12.ii.16 ; 6106).

Bewdley

63–71. Town Supply from boreholes (in L.M.S.) at Blackstone Rock (see p. 95), Wribbenhall parish :—

63. From old borehole ; from tap. (9.v.02 ; 612).
64. do. ; from borehole. (23.vii. 03 ; 1168).
65. do. ; tap. (26.iv.05 ; 1940).
66. do. ; tap. (29.x.06 ; 2532).
67. do. ; tap. (29.vi.08 ; 3079).
68. do. ; tap. (13.viii.12 ; 4784).
69. do. ; tap. (13.x.16 ; 6245).
70. do. ; tap. (22.i.20 ; 6935).
71. From new borehole ; from borehole. (19.xii.13 ; 5241). (For mineral analysis, see Table II, p. 177).

72. Black Barn Farm, Cleobury Road. Well, 25 ft., clay with shaly stone and rock. (C.M.). (16.xii.02 ; 927).
73. Dog Lane. Well, 35 ft., marl with sandstone. (Ditto). (18.xii.03 ; 1355).
74. Forest Lodge, Hitterhill. Well, 35–40 ft. (Ditto). (31.viii.04 ; 1702).
75. Welch Gate, Bewdley. Well, 80 ft., sandstone. (Ditto). (24.i.06 ; 2275).
76. Forest Lodge, Hitterhill. Spring, 2 ft. below surface. (Ditto). (31.viii.04 ; 1703).
77. Mill House, Long Bank. Well (new). Ditto). (29.xii.19 ; 6914).
78. Severn Side, Bewdley. Well, 80 ft. (L.M.S.). (29.vi.08 ; 3078).

Birlingham

79. Old well in field, 16 ft. deep, in sand and gravel. (S.D.). (1.iii.02 ; 545).
80. Schools, Birlingham. Old well, in gravel. (Ditto). (11.vi.02 ; 648).
81. Birlingham. Well, 15 ft., in sand. (Ditto). (5.xi.02 ; 890).

82. Woodfield Farm. Well, 10 ft., in sand and gravel. (Ditto). (11.v.04 ; 1520).
83. New Rectory. Well (new), 11 ft., in sand and gravel. (Ditto). (18.ii.11 ; 4302).
84. Spring from gravel, Eckington Road—at Bungalow. (Ditto). (26.v.22 ; 7542).

Birmingham

Welsh Supply. See Nos. 634, 635 below.

Birtsmorton

85. Birts Street. Well (new), 12 ft., sandstone rock. (? Arden Sandstone). (13.x.21 ; 7417).

Bishampton

86. Village supply. From the well in gravel (on L.L. clay) in Niblett's Orchard. (24.ii.11 ; 4311).
87. The same. (3.v.11 ; 4380).
88. The same. (3.ix.13 ; 5154).
89. Dean Lodge Farm. Well, 14 ft. (L.L.)—mineral water. (5.vii.19 ; 6705).

Blockley

90–94. Public Supply. From springs (issuing from Inferior Oolite and Cotteswold Sands overlying Upper Lias Clay) near Hailstone Farm, Bourton Wood, at the head of Dovedale.
90. Hydrant. (3.xii.01 ; 463).
91. Tap. (2.vi.09 ; 3649).
92. Tap. (4.v.11 ; 4381).
93. Tap. (5.ii.15 ; 5840).
94. Tap. (1.ix.16 ; 6213).
95. Public supply, Paxford. Spring (from gravel overlying L.L. clay). (1.ix.16 ; 6215).
96. The same. Sample taken from Tank. (29.x.01 ; 399).
97. The same. Sample from Tap. (29.x.01 ; 398).
98. Station Road, Blockley. Well in gravel and clay. (S.D. on L.L.). (16.i.07 ; 2590).
99. Bath Orchard Spring. (16.xi.11 ; 4591).

Bockleton

100. Wood Cottage. Spring (from O.R.S.). (25.xi.10 ; 4226).
101. Do. Well (new), 30 ft., clay marl, freestone and cornstone. (Ditto). (25.iv.12 ; 4693).
102. Do. Well, 20 ft., cornstone. (Birch Hill Limestones—O.R.S.). (20.v.13 ; 5021).
103. Bockleton Court. Spring from clay and cornstone. (Ditto). (9.ix.18 ; 6553).

Bransford

104. Braces Leigh. Well. (K.M.). (16.i.04 ; 1387).
105. The School House, Leigh Hurst. Well. (K.M.). (26.vii.07 ; 2772).

Bredon

106. Mitton Farm. Well, 60 ft. (L.L.)—mineral water. (15.v.15 ; —).
107. Mill End. Well, 9 ft., in gravel. (S.D.). (1.xii.15 ; 6074).
108. Council Cottages, Cheltenham Road, Kinsham. Well, 12 ft. in sand and gravel. (S.D. on L.L.). (1.ix.21 ; 7385).
109. Bredon village. Well, 30 ft., clay and marl. (L.L.). (29.xi.16 ; 6278).
Westmancote, Cottage Spring. See No. 649 below.

Bredon's Norton

110. Rectory Farm. Spring (from gravel on L.L.). (3.xii.15 ; 6077).

Bretforton

111. Stoneford Barn. New well, 29 ft. (L.L.)—mineral water. (18.iv.03 ; 1084).
112. New Street, Bretforton. Well in sand and gravel. (S.D. on L.L. clay). (10.i.20 ; 6923).

Bricklehampton

113. The Poplars. Well, 18 ft., sand and gravel. (S.D. on L.L.). (15.ii.13 ; 4933).

Broadwas

114. Stone Farm. Well, 33 ft. (K.M.). (21.x.11 ; 4576).
115. The same. (24.vi.16 ; 6179).

Broadway

116–121. Broadway Village Supply, from springs (issuing from Inferior Oolite and Cotteswold Sands and slipped portions of these rocks resting on Upper Lias clay). "Many analyses of these springs have been made and they are very constant in composition."—C.C.D.

116. Spring. (15.ix.10 ; 4137).
117. Main. (11.xi.10 ; 4207).
118. Tap. (4.iii.11 ; 4321).
119. Tap. (5.i.14 ; 5252).
120. Tap. (9.v.19 ; 6663).
121. Tap. (28.viii.23 ; 7868).

122. Spring, Farncombe House (from ditto). (1.v.18 ; 6512).
123. Spring, Middle Hill (from ditto), 2,000 gallons per hour. (14.iv.21 ; 7303).

Bromsgrove

124. High Street. Well, 16 ft. (L.K.S.). (10.vii.07 ; 2762).

Broom

125. The Rectory. Well. (L.K.S.). (27.i.10 ; 3921).
126. Church House. Well, 15 ft., sandstone. (Ditto). (2.ix.19 ; 6733).

Broughton Hackett

127. Hawkins Cottage. New well. (L.L.)—mineral water. (25.ii.03; 1004).
128. Garbage Hall. Well, sand and gravel, limestone. (S.D. overlying L.L.). (30.ix.11 ; 4529).

Bushley

129. Sarnhill Grange supply. Shallow-seated spring-water running off K.M. (19.ii.09 ; 3465).
130. Bushley Schools. Tap fed from reservoir supplied with very shallow-seated spring-water running off Rhaetic. (24.vi.10 ; 4064).
131. Near churchyard. Well, shallow in gravel and sand. (S.D.). (9.vii.13 ; 5099).
132. Church Farm. Well, 12 ft., marl (and ? gravel). (29.ix.14 ; 5701).
133. Doublegates Farm. Well, 20 ft., gravel. (S.D.). 27.iii.17 ; 6341).

Castlemorton

134. Eight Oaks Cottage. Well, 25 ft., marl. (K.M.). (17.viii.22 ;7634).

Chaceley

135. Hall Farm. Well. (K.M., ? with capping of gravel). (21.ix.15 ; 6030).
136. Chaceley. Well, 15 ft., gravel. (S.D. resting on K.M.). (18.viii.22 ; 7639).
137. Do. Well, 50 ft. Loam and clay. (Ditto). (2.x.22 ; 7673).

Chaddesley Corbett

138. Brockencote House. Well, 20 to 30 ft. (L.K.S.). (27.x.11 ; 4578).
139. Do. Spring. (From Ditto). (30.v.23 ; 7813).
140. Do. Chaddesley Brook at. (20.vii.20 ; 7152).
141. Cakebole. Well, 11 ft. (L.K.S.). (21.vi.13 ; 5075).
142. Kingscote House, Dobes Lane. (Ditto). (22.v.15 ; 5938).
143. Winterfold. Brook. Ram. (28.iv.17 ; 6354).
144. Bluntington House. Well, 80 ft. (L.K.S.). (12.vii.21 ; 7358).
145. Chaddesley Corbett. Well, 28 ft., hard sandstone. (Ditto). (19.vii.04 ; 1640).
146. 'Mary Knowle.' Boring, 300 ft. (Ditto, and U.M.S. and P.B.). (15.v.09 ; 3619).

Charlton

147. A new house, Charlton. Well (new), 10 ft., sand and gravel. (S.D.—River Terrace). (21.i.05 ; 1833).
148. Charlton. Well, 15 ft., sand and gravel. (Ditto). (1.ii.05 ; 1838).
149. Charlton. Well, 15 ft., sand and gravel. (Ditto). (18.i.11 ; 4256).
150. Limekiln Cottages, Charlton. Well (new), 32 ft., blue shale. (L.L.). (25.ix.07 ; 2850).
151. New cottages, Haselor. Well (new), 20 ft., Clay and stone. (Ditto). (4.xii.09 ; 3885).

Churchill, near Worcester

152. Churchill Spa. Spring from Lower Lias. The sample was not very satisfactory as the water had been muddied by the trampling of cattle. Mineral water, also a salt water. (6.x.04 ; 1745).
(For mineral analysis of another sample from the same spring, see p. 177, No. 152a).
153. Churchill 'Petrifying Spring.' 'Blue Lias.' (L.L.). (6.x.04 ; 1746)
154. The Rectory. Well, 60 ft. (Ditto). (2.xi.23 ; 7908).

Churchill, near Kidderminster

155. New House Farm, Blakedown. Well, 30 ft., sandstone. (U.M.S.). (14.xi.16 ; 6265).
156. Churchill Court. Well, 41 ft., sandstone. (Ditto). (21.viii.09 ; 3736).
157. Churchill Cottages. Well, 50 ft. U.M.S. (1.iv.14 ; 5371).

Church Lench

158. Sheriff's Lench. Spring. (? from sand and gravel on L.L.). (24.xi.20 ; 7216).
159. The same. (13.v.22 ; 7530).

Cleeve Prior

(See Nos. 233–235).

Clifton-on-Teme

160. Noak Lodge. Well, 42 ft. (O.R.S. *below* the Birch Hill Limestone horizon). (24.vii.12 ; 4774).
161. Gatley Cottages. Spring. (Ditto). (3.v.04 ; 1502).
162. In Clifton village. Spring. (O.R.S. *above* the Birch Hill Limestone horizon). 11.ii.14 ; 5300).
163. Hope Farm. Spring. (From O.R.S.). (11.xii.22 ; 7715).
164. Clifton-on-Teme Public Supply. From tap. Supply obtained from spring, from O.R.S., discharging into Sapey or Holloway Brook. See p. 46. (18.vi.24 ; —).
165. Sapey Brook, above point of entry of the spring mentioned in No. 164. (18.vi.24 ; —).

Cotheridge

166–169.. Blackfield Farm. Well, 42 ft. (K.M.)—mineral water.
166. (15.v.06 ; 2361). **167.** (12.ix.06 ; 2490).

168. (15.iv.07 ;—). **169.** (14.vi.11 ; 4423).
No. **169,** though clear, became turbid and brown on standing ; it had iron both in suspension and in solution.
170. Black field Farm. Well (new). " Near to the mineral-water well." (27.ix.07 ; 2847).

Cropthorne

171. Smokey Farm. Well, 22 ft., clay and pure limestone. (L.L.). (12.ix.03 ; 1282).
172. New cottages, Evesham Road. Well (new), 24 ft., sand and gravel. (S.D. on L.L.). (7.xi.08 ; 3276).
173. Police Station. Well, 25 ft. (10 ft. of water), gravel. (S.D.). (2.xii.08 ; 3298).
174. Freelands Farm. Well, 30 ft., gravel. (Ditto). (23.xi.20 ; 7214).

Crowle

175. In village. Well, 70 ft., Blue Lias. (L.L.). (10.iii.05 ; 1877).
176. School House. Well, Limestone and marl. (Ditto). (15.v.07 ; 2694).
177. Crowle Green. Well. (Ditto). (30.viii.07 ; 2820).
178. Malt House Cottages. Well, Limestone overlaid with blue clay. (Ditto)—mineral water. (23.ix.11 ; 4521).
179–181. Candy (' Caudy ') Well. Spring, from Blue clay, marl and sand. (Ditto, with ? traces of Superficial Deposits).
179. (23.ix.11 ; 4522).
180. (2.iv.12 ; 4688).
181. Sample taken after dry weather. (17.vi.14 ; 5531).

Defford

182. Village, practically in the centre. Well, 35 ft., in a mixture of gravel and clay (overlying L.L. clay). (14.vii.23 ; 7841).
183. School, Defford. Well. (L.L.)—Mineral Water. (6.ii.09 ; 3533).
184. Lunn's Well, Defford. Well (new), 31 ft., Blue Lias (L.L.). (4.viii.15). (Analysis of mineral constituents in Table II, p. 177).
185. Woodmancote, near Defford. Well. (L.L.)—Mineral Water. (6.ii.09 ; 3509).

Doddenham

186. Haines Green Farm House. Well, 80 ft., red marl (K.M.). (19.xii.03 ; 1356).
187. Doddenham Hall Farm. Well, 20 ft. (18.xii.15 ; 6084).
188. Upper Gurnox Farm (see p. 50). Well, 103 ft. (K.M. with some gypsum)—Mineral Water. (29.xi.22).
189. The same. (For mineral analysis see Table II, p. 177). (2.xii.22 ; 7710).
190. Upper Gurnox Farm, spring near. (On K.M.). (2.xii.22 ; 7711).
191. Banners Brook, spring near. (23.ix.12 ; 4819).
192. Knightwick Sanatorium. Well, 50 ft. (now disused ; at old wind-pump). (May Hill Sandstone). (14.i.03 ; 952).
193. The same. (For mineral analysis see Table II, p. 177). (8.vii.05 ; 2630, and 7.viii.05 ; 2083).
194. Knightwick Sanatorium. Well (now disused) at corner of lawn. (Do.). (13.xii.13 ; 5232).
195. The same. (24.vii.14 ; 5575).
196. The Tower House. Well (new), 145 ft., rock (Do.). (15.viii.14 ; 5620).
197. The same. (28.x.18 ; 6571).
198. Talbot Hotel, Knightsford Bridge. Well, 15 ft., marl (? heavy Temeside Alluvium). (2.ix.08 ; 3164).
199. Nipple Well. Sample taken after heavy rain. (Spring emerging in Lower Keuper Sandstone east of a fault to the west of which is Trappoid Breccia overlying May Hill Sandstone). (27.vi.24).

Dodderhill

200. Ridgway Cottages, Dodderhill. Well, red marl (K.M.). (14.vi.02 ; 651).

201. Astwood Road, Dodderhill. Well (new), 18 ft., marl (K.M.). (12.iv.20 ; 7015).

Droitwich

202. Tagwell Lane and East Worcestershire Waterworks Company's waters mixed. (18.ix.02 ; 794).

203. The same. (17.iv.05 ; 1931).
For East Worcestershire Waterworks Co.'s supply to Droitwich, see Nos. 210, 211 below.

204. Tagwell Lane, Droitwich, Pumping Station. (17.iv.05 ; 1930).

205. Droitwich Canal, 60 ft. distant from Mr. Wheeler's Farm, Ombersley Road—Salt. (3.xii.12 ; 4881).
For analyses of the Brine, see Nos. 663–668 below.

Dudley

For analyses of Saltwells Mineral Water, see Nos. 669–671 below.

East Worcestershire Waterworks Company

206. Burcot Pumping Station (see p. 136). From borehole. (22.1.12 ; 4616).

207. The same. (10.ii.20 ; 6980).
For older analyses from the Burcot borehole, see Nos. 636–638 below.

208. Washingstocks Pumping Station (see p. 139). From borehole. (2.v.13 ; 5012).

209. The same. (10.ii.20 ; 6981).

210. From taps in Droitwich. (17.v.13 ; 5020).

211. The same. (13.x.20 ; 7193).

212. From taps in Redditch. (22.ii.23 ; 7753).

213. The same. (3.x.23 ; 7894).

Eckington

214. Pershore Road. Well (new), 24 ft., sand and gravel ; layer of stone in clay at bottom (S.D. on L.L.). (4.vii.03 ; 1155).

215. Prospect House. Well, 30 ft., sand and gravel (Do.). (9.iv.04 ; 1456).

216. Avondale, Comberton Road. Well, 30 ft. [? gravel on] blue clay (? Do.). (7.x.18 ; 5560).

Eldersfield

217. Court. Well, 31 ft., rock and marl (K.M. and Arden Sandstone). (23.ii.06 ; 2305).

218. Link End Farm. Well, 20 ft., marl (K.M.). (17.i.17 ; 6293).

Evesham

219–226. Town Supply. (From springs issuing from Inferior Oolite and Cotteswold Sands, thrown out by the Upper Lias clay). All samples taken from taps.

219. (2. ix.07 ; 2822)
220. (15.i.10 ; —)
221. (14.ii.13 ; —)
222. (11.i.16 ; —)
223. (16.ii.20 ; —)
224. (9.vi.20 ; —)
225. (6.iii.23 ; —)
226. (1.i.24 ; —)

227. Castle Street. Well. Gravel near River Avon and on same level (S.D.). (11.vii.03 ; 1160).

228. Abbey Manor Farm. Well, 18 ft., gravel on blue clay (L.L.). (18.viii.16 ; 6204).

Evesham and Pebworth Joint Water Committee

229–236. From springs (issuing from the Inferior Oolite and Cotteswold Sands, thrown out by the Upper Lias clay).

229. Tap. (6.i.11 ; 4246).
230. Tap (Stanway Supply). (7.x.15 ; 6045).
231. Tap (Peartree Supply). (15.iii.16 ; 6126).
232. Peartree Spring. (24.ix.20; 7186).
233. Tap, Cleeve Prior. (2.viii.22 ; 7627).
234. The same. (13.ii.23 ; 7741).
235. The same. (31.x.23 ; 7903).
236. Tap, Wickhamford. (13.xii.23 ; 7927).

Feckenham

237. Shurnock. Well (new), 30 ft., marl (K.M. just below the Arden Sandstone). (1.xii.08 ; 3292).
238. Grove Farm. Well, 25 ft., marl and clay (L.L.). (15.ix.13 ; 5158).
239. The Square, Feckenham village. Well, 30 ft., ? marl (K.M.). (16.ix.19 ; 6758).
240. Edgeoak or Edgiock. Spring (? from sand and gravel on K.M.). (25.xi.19 ; 6837).
241. The Brook, Droitwich Road. Well, 25 ft., marl (K.M.). (28.xi.19 ; 6871).
242. Dunstall Court. Well (K.M.). (11.xii.19 ; 6884).

Astwood Bank.—

243. Infant School, Feckenham Road. Well, 20 ft., sand and gravel. (S.D.). (9.xi.01 ; 435).
244. Evesham Road. Well, 20 ft., ditto. (Ditto). (31.v.04 ; 1583).
245. ,, ,, ,, 20 ft., ditto. (Ditto). (31.v.04 ; 1587).
246. ,, ,, ,, 20 ft., ditto. (Ditto). (31.v.04 ; 1593).
247. Market Place ,, 20 ft., ditto. (Ditto). (10.viii.04 ; 1671).
248. Holly Cottages, Hunt End. Well, 25 ft., ditto. (Ditto). (11.x.05 ; 2168).
249. Chestnut Road. Well, 20 ft., ditto. (Ditto). (16.ix.10 ; 4149).

Fladbury

250. Broadway Lane. Well, 14 ft., sand and gravel (S.D.). (14.v.02 ; 619).
251. Fladbury Mill. Spring from sand and gravel on clay (issues from under garden land). (S.D. on L.L.). (15.xi.02 ; 900).
252. The Laurels. Well (16 ft.), sand and gravel (S.D.). (5.xii.08 ; 3303).
253. The same. (16.x.22 ; 7681).
254. The Laurels. Well (deepened to 30 ft.). (8.i.24 ; 7937).
255. Craycombe House. Spring from sand (S.D.). (18.x.17 ; 6431).

Flyford Flavell

256. Lower Church Farm—near house. Well (L.L.)—Mineral Water with odour of H_2S when sample was first taken. (26.x.04 ; 1751).
257. Lower Church Farm—in field. Well, 15 ft. (L.L.)—Mineral Water. (26 x.04 ; 1752).
258. Colley Place. Well (new), 15 ft. (L.L.). (10.iv.07 ; 2654).

Frankley

259. Yew Tree Farm. Spring. (29.iv.05 ; 1942).
260. Yew Tree Farm. Well, clay. (24.ii.06 ; 2306).
261. Yew Tree Cottages. Spring. (18.i.07 ; 2604).

Grafton Flyford

262. Well (26 years old), 28 ft. clay (L.L.)—? Chalybeate Water. (But see the mineral analysis in Table II, p. 177). (13.ix.02 ; 801).
263. Libbery Farm. Well (new), 14 ft., gravel (S.D. on L.L.). (6.v.12 ; 4701).

Great and Little Hampton

264. Little Hampton. Well (new), 16 ft. deep, blue clay (L.L.). (21.v.02 ; 623).
265. Hampton Spa. Well (L.L.)—Mineral Water. See p. 55. (For mineral analyses see Table II, p. 177, and also No. 659 below). (22.iv.21 ; 7314).

Great Witley

266. White House. Well (old) 50 ft. (L.K.S.). (1.viii.02 ; 714).
267. The same. (22.vii.21 ; 7363).
268. The same. (14.viii.22 ; 7632).
269. The Rectory. Well in white sand (L.K.S.). (3.vi.04 ; 1580).
270. Spring at foot of Abberley Hill now supplying Rectory and The White House (from L.K.S.). (22.vii.21 ; 7364).
271. The same. (14.viii.22 ; 7631).
272. Woodbury Hill, spring supplying Witley Court (from Trappoid Breccia overlying Silurian). (14.viii.21 ; 7369).

Grimley

273. Grimley village. Well (old and shallow) in gravel (on K.M.). (3.xii.02 ; 919).
274. The same. (7.ii.03 ; 977).
275. Monkwood Green. Well, 35 ft., red marl and sandstone (K.M.). (9.ii.05 ; 1845).
276. New bungalow, Sinton Green. Well (new), 30 ft. (K.M.). (12.xi.20 7204).

Guarlford

277. School, Guarlford. Well, under 30 ft. (K.M.). (8.vii.07 ; 2759).
278. Cherry Orchard. Well, 25 ft., marl (K.M.). (11.v.09 ; 3594).
279. Clevelode Road. Well, 20 ft., marl (K.M.). (30.ix.21 ; 7409).
280. Portocks End Farm. Well, 111 ft., marl (K.M.). (12.iii.15 ; 5880).
281. Portocks End Farm. Well (new), 70 ft., marl (K.M.). (30.vii.04 ; 1650).

Hadzor

282. Primsland End. Well (New), 35 ft., red marl (K.M.). (23.xi.01 ; 456).
283. Shernal Green. Well (new), Blue Lias (L.L.). (25.iv.03 ; 1095).
284. Dean Farm. Well, 20 ft., Blue Lias (L.L.)—Mineral Water. (7.iii.06 ; 2318).

Halesowen

285. Mucklow's Hill, spring above Messrs. Walter Somers & Co., Ltd. (9.vi.14 ; 5465).
286. Hagley Road. Well, Halesowen Sandstone (C.M.). (20.vi.14 ; 5516).
287. Mill Lane. Well, Halesowen Sandstone (C.M.) (23.x.15 ; 6052). (See also Nos. 490–492 below).

Hampton Lovett

288. Hampton Lovett. Well, 80 to 90 ft. (K.M.). (20.xii.02 ; 945).
289. Jackman's Hill. Well (new), red marl (K.M.). (4.vii.05 ; 2068).
290. The same. (20.xi.19 ; 6833).
291. Hampton Lovett. Well (new) 85 ft., red marl (K.M.). (19.iii.07 ; 2642).
292. Bryn Penrice, Hampton Lovett. Well, 90 ft. (K.M.). (24.i.11 ; 4269).

Hanbury

293. Vernon Arms. Well (150 years old), 25 ft. (K.M.). (19.xi.01 ; 451).
294. Rectory. Well, 60 ft. (K.M.). (16.x.17 ; 6435).
295. Bank Cottage, Hanbury Road. Well, 12 ft. (? L.L.)—Mineral Water. (20.ii.23 ; 7750).
296. Astwood Farm, near Stoke Works. Well (new), 15 ft., red marl (K.M.). (13.iv.07 ; 2660).

Hanley Castle

297. Gilbert's End, Hanley Swan. Well, 24 ft. deep in " Malvern Drift " (S.D.). (11.vi.12 ; 4731).
298. Boys' Home, Hanley Swan. Well, 20 ft. deep in " Malvern Drift " (S.D.). 18.vi.12 ; 4735).
299. The Bourne, Hanley Swan. Well, 14 ft. deep in marl (K.M.). (4.iii.13 ; 4944).
300. Hanley Hall. Well (new) 60 ft. (K.M.). (12.vi.03 ; 1143).
301. The Schools, Cross Hands. Well, marl (K.M.). (10.i.07 ; 2581).
302. Severn End. Well, 30 ft., marl (K.M.). (2.xi.08 ; 3270).

Hanley Child and Hanley William

303. Hooper's House, Broadheath, Hanley Child. Well, 24 ft., clay (O.R.S. above horizon of Birch Hill Limestones). (7.ix.09 ; 3751).
304. Lower Hanley Mill, Hanley Child. Spring (from neighbourhood of Birch Hill Limestones). (1.xii.09 ; 3872).
305. Hanley Court, Hanley William. Spring (from O.R.S. above the horizon of the Birch Hill Limestones), over 6 gallons per minute. (30.x.19 ; 6792).
306. Hanley Court, Hanley William. Spring (ditto), 2 gallons per minute. (30.x.19 ; 6793).

Hartlebury

307. Stour Hill, Wilden Lane. Well (new), 90 ft., red sandstome (L.K.S.). (30.v.07 ; 2710).
308. Hill Crescent, Summerfield. Well, 75 ft., sandstone (L.K.S.). (18.vi.09 ; 3681).
309. Perry Farm. Spring (from L.K.S.). (25.v.17 ; 6374).
310. Waresley House Farm. Well, 90 ft., red sandstone (L.K.S.). (7.xi.18 ; 6574).
311. Lincombe Hall. Well, 50 ft., red sandstone (L.K.S.). (16.vii.06 ; 2297).
312. The same. (16.v.18 ; 6516).

Hasbury

313. Spring Hill. Public Well, in rock, at side of road (C.M.) (14.xi.06 ; 2548).

Hill and Cakemore

314. Long Lane. Well, 20 ft., sandstone (C.M.). (13.i.14 ; 5251).

Hill and Moor

315. Lower Moor. Well (new), 12 ft., sand and gravel (S.D.). (3.vii.07 ; 2752).
316. Salters Lane, Lower Moor. Well (new), 8 ft., sand (S.D.). (11.ii.21 ; 7270).
317. Upper Moor. Well, 8 ft., sand and gravel (S.D.). (13.iii.09 ; 3512).
318. Mr. Sprout's Well, Hill. Well, 70 ft. (L.L.)—Mineral Water. (14.xi.08 ; 3392).

Himbleton

319. Harnil (Hornil or Hornhill), Earls Common. Well in blue clay (L.L.)—Mineral water. (11.xi.01 ; 441).
320. Church Cottages. Well in gravel (S.D. on L.L.). (20.x.06 ; 2517).
321. The same. (24.x.08 ; 3266).
322. Near Himbleton Manor. Well (new). (For mineral analysis see Table II, p. 177). (17.v.07 ; 2730).
323. Black Pit Lane. Well (new) 21 ft., Blue Lias (L.L.). (30.vi.09 ; 3688).

Holt

324. Holt Police Station. Well 85 ft. deep (L.K.S.). (4.v.03 ; 1098).
325. Wharf Hotel. Well, shallow. 30 yds. from River Severn (L.K.S.). (28.iii.05 ; 1896).
326. Holt Castle. Spring (from L.K.S.). (27.vi.08 ; 3073).

Inkberrow

327. Cladswell Spring from gravel (resting on K.M.). (16.ix.08 ; 3197).
328. Mearse Farm. Well (new) 40 ft., marl (K.M.). (10.ii.09 ; 3447).
329. Morton Hall. Well, 40 ft., gravel and sandstone (Arden Sandstone). (10.ii.10 ; 3929).
330. Morton Hall Farm. Well, 65 ft., marl and sandstone (K.M. and do.) Mineral water. (3.ix.10 ; 4130).

Kempsey

331. Draycot Lodge. Well 14 ft. (50 years old), sand (S.D. on K.M.). (7.ii.02 ; 526).
332. The Crown Inn. Well, 12 ft., sand and gravel (do.). Mineral water. (11.viii.03 ; 1230).
333. The same. (26.viii.18 ; 6546).
334. The Schools, Kempsey. Well, 45 ft., gravel and marl (Do.). (11.viii.03; 1235).
335. Roseleigh. Well, gravel and sand (Do.). (4.xi.03 ; 1332).
336. West Royd, Worcester Road. Well, sand and gravel (Do.). (14.vi.21 ; 7345).
337. Clerkenheap. Well (new), 18 ft., marl. (K.M.). (18.viii.14 ; 5623).

Kidderminster

338. Town Supply. From tap. (Water from boreholes in Bunter, see p. 111). (30.iii.14 ; 5361).
For analyses of water from three wells in the town see p. 204, Nos. 629–631.

Kidderminster Foreign

339. Bight Farm, Trimpley. Well, 30–35 ft., clay (O.R.S.). (6.v.20 ; 7064).

Kington

340. Cooksholme Farm. Well (new), 150 ft., blue clay (L.L.). Mineral water. (16.vi.09 ; —).

Knighton-on-Teme

341. Vicarage. Well, 75 ft., clay. (O.R.S. below Birch Hill Limestones). (30.iii.12 ; 4657).
342. Vicarage. Borehole, 188 ft., red sandstone, first bored. (O.R.S. below Birch Hill Limestones). (30.iii.12 ; 4660).
343. Vicarage. On pumping water became saline. (3.ii.13 ; 4923).
344. Do. On standing. (11.ii.13 ; —).
345. Newnham Bridge. Well, 25 ft., gravel. (S.D. Valley Gravels). (14.iii.23 ; 7775).

Leigh

346. Sandlin Farm, Leigh Sinton. Well, 37 ft., clay. (K.M.). (21.vi.07 ; 2734).
347. Clerkenhill Cottage. Well (new), 71 ft., marl. (Do.). (9.viii.07 ; 2785).
348. Brockamin. The Great House Farm. Well 42 ft. (Do.). (24.xi.09 ; 3865).
349. Bank Farm Leigh. Well, 27 ft. (Do.). (1.ix.10 ; 4127).

Lindridge

350. The Moor. Well, " deep." (? through Alluvium into O.R.S. below the Birch Hill Limestone horizon). (9.x.22 ; 7676).
351. The Hatch Farm. Well, 39 ft., red sandstone (O.R.S. below the Birch Hill Limestone horizon). (19.ix.04 ; 1717).
352. The Hatch Farm. Well (new), 12 ft., marl (O.R.S.). (10.iii.06 ; 2321).

Longdon

353. Red House Farm. Well, 63 ft. (K.M.). (5.i.05 ; 1822).

Lower Sapey

354. Oxhall Farm. Spring (O.R.S.). (21.xii.07 ; 2928).
355. Waters Farm. Strong spring from freestone (O.R.S.) at head of small dingle with cornstone (Birch Hill Limestones) underneath. (18.ii.13 ; 4935).

Lulsley

356. Black's Well Spring (from U.M.S.). (5.xi.12 ; 4856).
357. Ravenhill Court. Well, marl and clay (K.M.). (28.ii.16 ; 6120).

Malvern

" Malvern Waters "—

358. Hay Well, Great Malvern. Hill water that has flowed for a short distance over K.M. (30.ix.05 ; 2158).
359. Tudor Well, Great Malvern. Do. (20.v.05 ; 1974).
360. Rushy Valley Spring, Great Malvern. Hill water taken as high up as possible, just under the 900-ft. contour-line. (12.vi.11 ; 4414).
361. The same. (24.xi.17 ; 6461).
362. The same. Green Valley, upper spring in. (22.ii.24 ; —). See also pp. 178, 205, No. 633.
363. St. Ann's Well, Great Malvern. Hill water. (21.ii.24 ; —). (For an old analysis, see No. 653 below).
364. Holy Well, Malvern Wells. (From pipe). Hill water. (20.x.03 ; 1323).
(For an old analysis, see No. 654 below).
365. The same. (2.xi.23 ; 7907).
366. Royal Malvern Spa (Colwall parish, Herefordshire). (28.i.24 ; —).

Various—

367. Spring (see p. 125) in Malvern Railway Tunnel at Pumping Station. (27.vii.08 ; 3114). Most of the water from Limestone. Tunnel and pumping station closed down in 1927. (For another analysis of this spring see pp. 178, 205, No. 632).
368. Pewtriss, Putress or Putriss, or Prime's Well. Fault spring. (a) after heavy rainstorm. (15.viii.02 ; 736).
369. The same. (b) containing no surface water. (20.iii.15 ; 5883).
370. From tank, fed by spring near the Westminster Hotel, West Malvern. Hill water. (29.x.09 ; 3817).
371. Cowleigh (or Cowley) Spout. (25.xi.05 ; 2221).
372. The same. (For mineral analysis see Table II, p. 177). (15.ii.23 ; —).
Green Valley, Upper Spring in. See No. 633 below.

PUBLIC SUPPLY—

373–379. Bromsberrow Pumping Station (Malvern U.D.C.). Borehole, 200 ft. deep, in U.M.S. See p. 124.

373. (4.v.05 ; 1945).
374. (28.vi.05 ; 2045).
375. (9.vi.10 ; 4046).
376. (28.x.14 ; —).
377. (16.xi.20 ; 7208).
378. (4.v.21 ; 7313).
379. (9.x.22 ; 7678).

(For mineral analyses of 373 and 376 see Table II, p. 177).

380, 381. Public temporary emergency supply. From [first] borehole at Gas Works, Malvern Link, through K.M. into L.K.S.

380. From borehole at 880 [878] ft. depth. (29.xii.02 ; 940).
381. The same. From ditto after 87 hours continuous pumping. (31.xii.02 ; 941).

Martley

382. School. Well, 32 ft., red marl (K.M.). (18.xii.03 ; 1353).
383. The same. (16.vi.08 ; 3062).
384. Rectory. Well, 25 ft., marl and red sandstone (Keuper). (5.iv.07 ; 2823).
385. Prickley Cottages. Well, limestone (Wenlock Limestone—Silurian). (23.v.14 ; 5450).
386. Barbers. Well, 53 ft., sandstone (L.K.S.). (12.xii.07 ; 2925).

Naunton Beauchamp

387. Naunton Beauchamp. Well (L.L.)—Mineral Water. (21.x.08 ; 3362).
388. Naunton Beauchamp. Well (? L.L.). (21.x.08 ; 3366).
389. Grove Farm Cottages. Well, 17 ft. " Blue clay over stone " (L.L.). (13.viii.10 ; 4112).
390. Piddle Brook at Naunton Beauchamp, but not in flood. (21.x.08 ; 3365).

Netherton

391. Netherton. Well, 15 ft., sand and gravel (S.D. on L.L.). (24.iii.09 ; 3549).
392. Haselor Lane. Netherton. Well, 15 ft. " Sand and gravel " (Ditto). (10.i.22 ; 7469).

North Bromsgrove

393. Barnsley Hall. New borehole (see page 127). (For mineral analysis, see Table II, p. 178.) (9.iii.03 ; 1016).
394. The same. (19.x.07 ; 2868).
395. The same. (19.x.07 ; 2869).
396. The same. Old borehole (see page 127). (13.xii.05 ; 2238). Sample $2\frac{1}{2}$ years old.
397. The same. (6.v.10 ; 4004).

Burcot borehole, see Nos. 206, 207 above, and 636–638 below.

North Claines

390–400. Fernill Heath :—

398. Station Lane. Well, red marl (K.M.). (28.i.02 ; 519).
399. Station Lane. Well (new), gravel (S.D. on K.M.) (28.vii.06 ; 2452).
400. Bungalow, Worcester Road. Well (new) 25 ft. (30,vii.23 ; 7853).

401. Raven Cottage, Droitwich Road, Claines. Well (new), 25 ft., Marl (K.M.). (19.viii.08 ; 3152).

North Hallow

402. Broadheath Common. Well (new), 33 ft., marl (K.M.). (22.xii.05 ; 2244).
403. Peachley Grange. Well 30 ft., marl (Do.). (11.vi.06 ; 2400).

404. Heathmere, Lower Broadheath. Well, 43 ft., marl (K.M.). (8.xi.10 ; 4208).
405. The Mill, ,, ,, ,, 29 ft. ,, (Do.). (16.v.14 ; 5441).

Norton and Lenchwick

406. Norton. Well, 15 ft., clay (L.L.). (14.i.02 ; 502).
407. Lenchwick. Well, 35 ft., clay (Do.) (; 505).
408. ,, ,, 45 ft., ,, (Do.) (; 506).
409. ,, ,, 50 ft., ,, (Do.) (; 507).
410. Counsel Green Spring—Norton village supply. From sand and gravel (S.D. on L.L.). (9.v.02 ; 613).
411. The same. (25.x.10 ; 4187).
412. Hipton Hill, Norton. Spring (from ? gravel resting on L.L.). (31.vii.23 ; 7854).

Norton-juxta-Kempsey

413. Norton. Well, 70 ft., marl (K.M.). (22.iii.05 ; 1888).
414. New Coppice Cottage. Norton. Well, 15 ft., gravel (S.D.). (29.ix.08 ; 3213).
415. Norton Grange. Well, 110 ft., marl (K.M.). (19.ii.09 ; 3544).
416. Wood Hall, Norton. Well, (about 80 ft., in Do.). (19.ii.09 ; 3545).
417. Eastfield, Hatfield Norton. Well, (about 80 ft. Do.)—Low salt. (18.iii.09 ; 3524).

Offenham

418. School House. Well, 11 ft., gravel and clay (S.D.). (15.x.03 ; 1320).
419. The Schools. Well (new), 15 ft., gravel and sand (Do.). (19.ix.05 ; 2146).
420. Vicarage. Well, 18 ft., gravel (Do.). (9.x.06 ; 2510).
421. Post Office. Well, 10 ft., sand and marl (Do.). (18.vi.09 ; 3669).

Oldbury

See Nos. 675, 676 below.

Ombersley

422. Ombersley House. Well (new), 13 ft., red sandstone (L.K.S.). (21.iii.03 ; 1049).
423. Woodfield Cedars. Well, 40 ft., red sandstone (Do.). (5.i.06 ; 2253).
424. The same, deepened to 127 ft. by boring (Do.). (12.vi.07 ; 2726).

Orleton

425. Orleton Court. Spring, clay (from O.R.S. below horizon of Birch Hill Limestones). (2.viii.10 ; 4098).
426. Orleton House. (Middle House) Well, 12 ft., limestone (O.R.S.). (8.ix.09 ; 3753).

Overbury

427. Village supply (at School). From spring(from Inferior Oolite, thrown out by the Upper Lias clay) in Overbury Park, Bredon Hill. (29.viii.06 ; 2481).

Pensax

428. Mount Pleasant, Mineth Wood. Well, 21 ft., " sandstone " (? C.M.). (11.iii.07 ; 2640).
429. Fox House, Mineth Wood. Well, 60 ft. (C.M.). (6.v.07 ; 2682).
430. Yew Tree Cottage, Pensax. Spring (C.M.). (25.x.10 ; 4188).

Peopleton

431. Seaford Grange. Well (L.L.)—Mineral Water. (21.x.08 ; 3367).

Pershore Holy Cross

432. Atlas Works, near Pershore Station. Well, 16 ft., in sand and gravel (S.D.) over blue (L.L.) clay. (26.x.01 ; 396).
433. Coventry Terrace, near Pershore Station. Well, 12 ft., in field (in L.L. clay). H_2S. (21.ix.07 ; 2835).

434. The same. Another well, 60 ft., (in L.L. clay)—Mineral water. (21.ix.07 ; 2836).

435. Messrs. Woodward & Co., Mineral Water Manufacturers, New Road. Well (? in Do.)—Mineral water (For mineral analysis see Table II, p. 178). (5.iii.10 ; 3973).

436. Green Villas, Drake's Broughton. Well (new), 50 ft. " Blue clay " (Do.)—Mineral water. (6.vii.07 ; —).

437. Drake's Broughton. Well, 20 ft. " Blue clay " (Do.)—Mineral water. (7.x.18 ; 6559).

438. Station Road. Old well, 20 ft. in sand (S.D.—River Terrace—resting on L.L. clay). (29.x.21 ; 7432).

439. Housing Scheme, Hurst Park Cottages, Station Road. Well, 30 ft., sand and clay (Do.). (17.v.22 ; 7531).

440–445. The same. Other wells all in the same field as No. 439 ; all about 30 ft. deep. (17.v.22 ; 7532–7).

Pershore St. Andrews

446. Pensham Hill. Well, 17 ft., in sand and gravel (S.D. on L.L.). (17.ii.21 ; 7275).

447. Lower Pensham. Well, 7 ft., ,, ,, ,, (Do.) (24.v.21 ; 7327)

448. Building scheme, Pensham. Well, 25 ft. in gravel (Do.)—Mineral water. (13.xii.21 ; 7451).

449. Cottage Hospital, Difford Road. Well in gravel (Do.). (31.x.08 ; 3371).

Pinvin

450. Salt Boxes, Pinvin. Well, 21 ft., blue (L.L.) clay—Mineral water. (4.i.11 ; 4244).

Pirton

451. Pirton Court Cottages. Well, 15 ft. (K.M.). (5.xi.04 ; 1770).

Powick

452. Powick Court. Well, 10 ft., in sand and gravel (S.D.). (23.iii.03 ; 1058).

453. School House, Callow End. Well, " gravel and marl " (S.D. on K.M.). (2.xii.02 ; 918).

454. Horse Hill, Powick-Upton road, Callow End. Well 120 ft. (K.M. ? with capping of S.D.). (15.xi.13 ; 5218).

455. Beauchamp Court. Well, 15 ft., gravel (S.D. on K.M.). (25.iii.18 ; 6501).

456. Stanbrook Abbey. Well, 25 ft., marl (K.M.). (25.ii.21 ; 7283).

457. Kings End. Well, 20 ft., sand and marl (S.D. on K.M.). (24.x.17 ; 6445).

458, Upton-on-Severn R.D.C. Undertaking (from sand and gravel resting on K.M.). (24.iii.11 ; 4338).

Redditch

For East Worcestershire Waterworks Co.'s supply, see Nos. 212, 213 above.

Redmarley D'Abitôt

See Nos. 625–628.

Ribbesford

459. Ribbesford Hall supply (spring from C.M.). (25.v.12 ; 4717).

460. The same. (17.i.16 ; 6093).

Ripple

461. County Police Station. Well (new), 17 ft., clay and marl (K.M.). (14.xi.06 ; 2547).

462. Grove House. Well, 20 ft., marl (K.M.). (12.xii.21 ; 7450).

463. Bank Farm. Well, 20 ft., marl and sandstone at bottom of well (K.M. and Arden Sandstone). (13.vi.11 ; 4415).

Rochford

464. Lower House. Well, 12 ft., gravel (S.D.). (19.vi.05 ; 2030).
465. Lower Rochford Farm. Spring, sandstone (O.R.S.). (23.vii.10 ; 4083).
466. Rochford House. Well, 30 ft. (O.R.S.). (15.iv.18 ; 6509).

Rock

467. The Tyning, Far Forest. Well, 38 ft. (C.M.). (23.vii.23 ; 7850).
468. Blakemore Farm. Spring (from C.M.). (25.iv.13 ; 5003).

Romsley

469. St. Kenelm's Hall, Back Lane. Well, marl (Keele Beds—C.M.). (3.viii.06 ; 2455).
470. The Rectory. Well, 30 ft., " sandstone " (Do.). (25.viii.15 ; 6013).
471. The same. (11.ix.16 ; 6223).
472. The same. (15.v.17 ; 6371).

Rushock

473. The Rectory. Well, 90 ft., clay (K.M.).—Mineral water. (15.xii.09 ; 3895).

St. John in Bedwardine County

474. Rosemont, Upper Broadheath. Well (new), 48 ft., Marl (K.M.). (16.vii.09 ; 3709).

Severn Stoke

475. Kinnersley. Well (new), 40 ft., marl (K.M.). (26.viii.15 ; 6016).
476. Kinnersley. Well (new), 36 ft., marl (K.M.). (13.ix.15 ; 6026).

Shelsley Beauchamp, Shelsley Kings, Shelsley Walsh

477. New School House, Shelsley Beauchamp. Well, 28 ft., gravel (S.D.—Teme-side Valley Gravel. (23.viii.09 ; 3739).
478. The Grange Cottages, Shelsley Kings. Spring, red marl (O.R.S.). (3.ii.08 ; 2954).
479. New cottages, Shelsley Kings. Well (new), 30 ft., gravel (S.D.—Teme-side Valley Gravel). (10.vi.09 ; 3668).
480. Shelsley Walsh. Well, 12 ft., marl underlying limestone (O.R.S.—Marl underlying ? Birch Hill Limestones). (18.viii.08 ; 3146).

Shipston-on-Stour

481–487. Public supply (from spring at Ebrington from Middle Lias ; see p. 80)—from taps.

481. 4.iii.03 ; 1017).
482. (31.vii.07 ; 2776).
483. (16.xii.08 ; 3308).
484. (29.iv.11 ; 4376).
485. (9.vi.13 ; 5051).
486. (1.ii.15 ; 5839).
487. (1.ix.16 ; 6214).

Shrawley

488. Cart House Cottages. Well (old, deep), sandstone (L.K.S.). (7.ii.02 ; 525).
489. Shrawley Wood House. Well, sandstone (22 ft. to water, 5 ft. of water) (L.K.S.). (18.vi.06 ; 2406).

South Staffordshire Waterworks Water

(Sources of supply are wells and headings in Triassic sandstones and conglomerates).

490. Tap at Great Cornbow, Halesowen. (7.i.11 ; 4250).
491. Tap at Council Offices, Halesowen. (24.i.11 ; 4285).
492. The same. (14.ii.12 ; 4626).

(For taps in Oldbury, see Nos. 675, 676 below).

Stanford-on-Teme

493. Noverton. Well, 45 ft., red marl (? heavy Teme-side Alluvium). (8.x.04 ; 1742).
494. Shelsley Bank, Stanford Bridge. Well, 60 ft. (O.R.S. below horizon of Birch Hill Limestones). (7.v.08 ; 3021).
495. Old mill. Spring from limestone 100 yds. from mill (from cornstone in O.R.S.). (18.xi.08 ; —).
496. Noverton Cottages. Well, 5 ft., sandstone (O.R.S.). (3.viii.09 ; 3719).
497. Noverton. Well, 45 ft., sandstone (O.R.S.). (1.vi.11 ; 4405).
498. The School Cottages. Spring (from O.R.S.). (9.iii.15 ; 5870).
499. Southstone Rock. Spring (" Petrifying ") at The Hermitage which makes the exceptional deposit of travertine. See p. 200. (For further analysis see Table II, p. 177). (12.iii.24 ; —).
500. Stream close to and north of The Hermitage, but above point where the spring " petrifying " flows into it. (12.iii.24 ; —).

Staunton

501. Staunton Court. Well, 23 ft. (K.M.). (6.iv.08 ; 2997).
502. The same. (24.v.10 ; 4017).
503. Little Pike House. Well, 23 ft. (K.M.). (17.xii.12 ; 4887).

Stockton-on-Teme

504. Rectory. Well, 45 ft., marl (O.R.S., below horizon of Birch Hill Limestones). (11.ix.09 ; 3760).

Stoke Prior

For analyses, see Nos. 641–644, 660–662 below.

Stoulton

505. Egdon Lane. Well (L.L.). (20.i.09 ; 3458).
506. Bird in Hand Inn. Well, 15 ft., gravel (S.D. on L.L.). (6.xii.22 ; 7713).

Stourbridge

STOURBRIDGE AND DISTRICT WATER BOARD.

507. Millmeadow Pumping Station. Borehole (see p. 144). The high chlorides may be due to the presence of marl beds in the rocks. The tarry odour may be due to the water mains being treated with D. Angus Smith's solution. (18.xii.11 ; —).
(For an older analysis, see No. 658 below).
508. From tap—Town Supply. Water derived from two sources—a mixed sample. (4.iii.14 ; 5321).
509. Coalbournbrook Pumping Station. (pp. 141, 142) (4.vii.14 ; 5535).
510. Do. Borehole recently deepened. (6.viii.14 ; 5606).
511. From taps—Town Supply from Coalbournbrook Pumping Station. (3.ix.14 ; 5671).
512. The same. (7.i.15 ; 5812).
513. The same. (3.vi.15 ; 5948 (a)).
514. The same. (6.i.16 ; 6088).
515. The same. (25.v.23 ; —).

Stourport

516. Bridge Street. Well, 15 ft., gravel (S.D.). (22.x.15 ; 6051).
517. Severn Valley Mills (see p. 133). Gravel and rock (S.D. on U.M.S.). (30.iv.19 ; 6645).

Strensham

518. Lower Strensham. Well (L.L.). Mineral water. (6.ii.09 ; 3506).
519. Moat House, spring into tank. Sample from tank. (15.i.10 ; 3916).
520. Strensham Artesian well (new—200 ft.). (27.viii.10 ; 4119).
521. The same. (17.ix.10 ; 4154).
522. The same. (17.viii.11 ; 4474).

Suckley

523. Hall House. Spring. (7.vi.02 ; 643).
524. Grove Hill. Well, 70 ft., rock and clay lower (3.vi.04 ; 1569).
525. The same. (31.vii.11 ; 5133).
526. Baston Hall. Spring from limestone (Woolhope Limestone—Silurian). (11.x.04 ; 1743).
527. Tan House, Longley Green. Well, 30 ft. (Ludlow—Silurian). 26.x.10 ; 4189).
528. The Stocks. Well. (14.viii.11 ; 4470).

Teddington

529. Spring piped to village (from Sandy Beds of the Middle Lias in depression between Oxenton Hill and The Knolls). (15.ix.22 ; 7661).

Tenbury

530. Berrington Road. Well, 48 ft., red marl (O.R.S. below horizon of Birch Hill Limestones.) (16.iii.11 ; 4336).
531. St. Michael's College. Well, 30–40 ft., sandstone. (Do.). (30.i.14 ; 5279).
532. The same. New supply from spring (from O.R.S.). (30.iii.14 ; 5359).
533. The same. Well (new) (O.R.S.). (13.vi.14 ; 5483).
534. Tenbury Supply. Spring (from Cornbrook Sandstone, Lower Carboniferous, formerly " Millstone Grit ") in Studley Tunnel of the Birmingham Corporation's Elan Aqueduct, Clee Hill. (15.v.03 ; 1112).
535. The same. (23.xii.10 ; 4239).
536. Tenbury Supply. From tap. (19.vi.23 ; 7821).
537. The Crow Orchard (or present Spa) Well. (1.xii.11 ; —).
(For a mineral analysis see Table II, p. 178, and for an old analysis see No. 657 below).
Original Mineral Well. See Nos. 655, 656 below.

Throckmorton

538. New farm house, Tilesford. Well (new) 18 ft., blue clay (L.L.). (1.ix.09 ; 3743).

Tibberton

539. Foredraft. Well, marl (K.M.). Mineral water. (21.iii.12 ; 4655).

Tidmington

540. Mill. Well, 20 ft., Lower Lias. (9.vi.13 ; 5052).

Tredington

541. Longdon Cottages, Darlingscott. Well (L.L.). Mineral water. 285 parts of SO_3 per 100,000 were found in this water. (11.iii.05 ; 1881).
542. Pool House, Armscott. Borehole (through L.L., Rhaetic, K.M., and 7 ft. into L.K.S. See p. 89). (18.vi.09 ; 3618).
543. The same. (25.viii.09 ; 3746).

Tutnall and Cobley

544. Hewell Park. Spring from soft sandstone (L.K.S.). (11.iv.02 ; 588).
545. Oxleasows Farm, Tardebigge. Well, 60 ft., sandstone (L.K.S.) (20.viii.21 ; 7376).

Upper Arley

546. Arley Vicarage supply. Spring from " sandstone and clay " (? C.M.). (23.ii.04 ; 1400).
547. Spring from C.M., less than ¼ mile below churchyard. (23.ii.04 ; 1401).
548. Hillfields House. Well, 40 ft. in " sandstone." (28.i.05 ; 1836).
549. The same. (7.x.08 ; 3229).
550. Cherry Orchard Farm, Pound Green. Well, 30 ft. in " marl " (C.M.). (21.xii.18 ; 6590).
551. Hexton's Farm. Spring in meadow (from Enville Beds overlying C.M.). (2.xii.22 ; 7709).
552. Arley Castle supply. Spring from C.M. (16.x.23 ; 7897).
553. Arley Castle. Well, 6 ft., catching water from three springs (from C.M.). 4.iv.22 ; 7507).
554. Button Oak (just over county-boundary in Shropshire). Spring, from C.M. (18.viii.19 ; 6726).

Upton-on-Severn

RED HILL BORING (through K.M. into L.K.S. ; see p. 91).
555–557. From borehole.
555. When 1,300 ft. deep (5.ii.10 ; —).
556. When 1,600 ft. deep ; after 5 days' continuous pumping with air lift (13.x.11 ; 4563).
557. When 1,700 ft. deep. Temperature 66°F. (30.iv.13 ; —).
558–561. Water overflowing at surface.
558. (15.v.13 ; —).
559 (30.v.13 ; 5034).
560. (4.xi.13 ; 5211).
561. (17.i.20 ; —).
(For mineral analyses of 556, 557, and 561 see Table II, p. 178).
It is of interest to note that these deep-well waters contain high free ammonia.

Upton Snodsbury

562. Bow Wood Spring. Piped to tank, which supplies tap opposite Royal Oak Inn. Sample from tap. (29.i.09 ; 3492).
563. Cowsden. Well (new), 20 ft., blue clay (L.L.)—Mineral water. (14.x.11 ; 4553).
564. Cowsden Hall. Well, 25 ft. (? L.L.). (23.ix.16 ; 6233).
565. Cowsden Croft. Well, 22 ft. (L.L.). (23.ix.16 ; 6234).

Wick (near Pershore)

566. Glenmore Farm. Well (new), 8 ft., sand and gravel (S.D. on L.L.). (11.iii.03 ; 1033).
567. Endon House. Well, 13 ft., gravel over blue lias (Ditto). (6.i.10 ; 3903).
568. Evesham Road. Well, 20 ft., sand and gravel (Ditto). (16.viii.11 ; 4473).
569. New Lodge, Endon. Well, 23 ft., sand and gravel (Ditto). (28.iv.15 ; 5919).

Wickhamford

(See No. 236)

Wollaston (near Stourbridge)

570. Vicarage Road, Wollaston. Well, 80 ft., " sandstone " (P.B.). (22.iv.07 ; 2664).

Wolverley

571. Lea Castle. Borehole, 180 ft. (Bunter). (26.v.23 ; 7812).
572. The Old Forge. Well, 4 ft., red sandstone (? Bunter P.B.). (14.x.12 ; 4832).
COOKLEY :—
573. Lime Cottages, Cornsall. Well, 20 ft., sand (P.B.). (19.v.20 ; 7075).
574. Rock Cottages, Cornsall. Well, 15 ft., rock (P.B.). (19.v.20 ; (7076).
575. The Vicarage, Cookley. Well, 30 ft., sandstone (P.B.). (7.vi.20 ; 7104).

576. Foundry Bank Cottages. Well, 60 ft., sandstone (P.B.). (22.vii.22 ; 7590).
577. Myrtle Cottages. Well, 40 to 50 ft., sandstone (P.B.). (26.vii.22 ; 7597).
578. Islandpool, Cookley. Spring (from U.M.S.). (4.ix.13 ; 5156).
579. Debdale Lane, Cookley. Spring (from P.B.). (15.v.23 ; 7802).
(For Wolverley Waterworks, see Nos. 672–674 below).

Worcester

580. Broughton Lodge, St. John. Well (old), sand and gravel. (6.vii.04 ; 1632).
581. Diglis Lock. Well, on island, 15 ft. deep. (2.ii.05 ; 35A.).
See also St. John in Bedwardine County, above.

Wribbenhall

582. Spring Grove. Well, 60 ft. (L.M.S.). (31.x.10 ; 4196).
583. The Lodge, Spring Grove. Well, 40 ft., sandy rock (L.M.S.). (13.vii.17 ; 6398).
584. No. 6 Ivy Cottage. Well, 30 ft. (40 years old), sand and sandstone (L.M.S.). (15.ix.02 ; 791).
585. Meadowside, Habberley Road. Well, 20 ft., sandstone (L.M.S.). (7.vi.17 ; 6381).

Wychbold

586. Paper Mill Cottages. Well (new), red marl (K.M.). (27.iv.07 ; 2675)
587. The Hollies. Well (K.M.). (4.iii.10 ; 3958).

Wythall

588. Grimes Hill. Well (new). (7.ix.21 ; 7406).
589. Bungalow on Alcester Road, spring near. (9.ix.22 ; 7652).

The (Stratford) Avon and Tributaries

River Avon. See Nos. 645, 646 below.
River Arrow.

590. At Ipsley (Warwicks. ; see p. 7). (10.ix.10 ; 4138).
591. Above Ipsley. (20.ix.10 ; 4151).
592, 594–596. Below Ipsley.
592. (20.ix.10 ; 4153). **595.** (25.xi.19 ; 6838).
594. (8.viii.16 ; 6200). **596.** (13.v.20 ; 7071).
593. Below Ipsley, after heavy rain. (20.i.15 ; 5825).

Piddle or Wyre Brook. See No. 647 below and 390 above.
Bow or Besford Brook.

597. At Drakes Broughton, Pershore Holy Cross Parish. At time of plenty of water. (The head waters drain tracts of K.M. ; but the bulk of the drainage is off L.L. with local but comparatively rare S.D.). (31.x.08 ; 3374).

Carrant Brook.

(Flows along S. side of Bredon parish, and enters the River Avon immediately above Tewkesbury. Drains mostly a L.L. clay tract with local S.D.).
598. Sample taken at Tewkesbury. The pink colour was due to micro-organisms. (23.vi.14 ; 5517).
Minor Tributaries. See 648, 650–652 below.

River Severn and Tributaries

River Severn.

599. At Blackstone Rock, about ¾ mile below Bewdley. (19.xii.13 ; 5242).
600. The same. (13.x.16 ; 6247).
601. At Worcester. Much flood-water up country. *Unfiltered.* (5.ii.23 1059A).

602. At Worcester. At end of long period of dry weather. *Unfiltered.* (3.viii.21 ; 977A). River Salwarpe enters River Severn a few miles above Worcester and is very saline at times.
603. At Worcester. At end of a dry period. *Filtered.* (28.vi.22 ; 1028A).
604. At Worcester. During June flood of 1924 : 22 ft. above summer level. *Unfiltered.* (2.vi.24 ; 1137A).

CAREYS BROOK (p. 6).
(Drains a K.M. tract, with rare and local S.D.).
605. At Penstock. (11.viii.09 ; 3728).
606–611. County and City Mental Hospital, Powick.
606. (2.i.18 ; 6477).
607. (25.vi.20 ; 7124).
608. (18.xii.20 ; 7230).
609. Filtered. (10.viii.21 ; —).
610. During drought. (10.viii.21; —).
611. (27.xi.22 ; 7703).

RIVER TEME (p. 6).
612. Ankerdine Farm House, 150 yds. above. Stream normal. (17.vii.06 ; 2448).
613–617. At Knightwick Sanatorium.
613. Before filtration. (23.iv.09 ; 3576).
614. After do. (28.vi.15 ; 5969).
615. Before do. (11.iii.21 ; —).
616. After do. (14.iii.21 ; —).
617. Stream in flood. (7.iii.23 ; 7771).
618. Near Powick Bridge. (6.iii.06 ; 2313).
619. At Powick Bridge. Stream normal. (21.ii.21 ; 7279).
620. Laughern Brook (a tributary of R. Teme). (Drains a tract of K.M. with local S.D.). (22.vi.04 ; —).

RIVER SALWARPE (p. 7).
(The head waters drain Trappoid Breccia, P.B., U.M.S. and L.K.S., but for the most part the river flows over and receives drainage from K.M. with local S.D.).
621. Collected at Wychbold. (21.vii.09 ; 3713).
622. ,, before entering the Borough of Droitwich. (3.iii.02 ; —).
623. ,, above Droitwich Sewage Farm. (3.iii.02 ; —).
624. ,, below ,, ,, ,, (3.iii.02 ; —).

625–628. Redmarley D'Abitôt. Mineral Water.[1] See Table II, p. 177.
625. Shallow well near bridge over River Leadon, but in Pauntley parish, Glos. (Fig. 3, p. 75, No. 2).
626. The same.
627. Spring close to bridge over R. Leadon, and discharging into the river, but in Redmarley parish, Worcs. (Fig. 3, p. 75, No. 4).
628. Spring (" Pauntley Spa," disused) discharging into R. Leadon, but in Pauntley, Glos. (Fig. 3, p. 75, No. 6).

ANALYSES IN TABLES III AND IV

(Reduced to parts per 100,000 and degrees Clark—see p. 149).

629–631. Kidderminster.
629. Messrs. Brinton and Lewis's Carpet Mill. Well, depth 160 ft. Temperature of water, 12.2°C. April 28th, 1870.[2]
630. Alderman Tovey's Yard. Well, shallow. April 29th, 1870.[3]
631. " Three Tuns " Yard. Well, shallow. April 29th, 1870.[3]

[1] Duncan, C. C., and L. Richardson, *Proc. Cotteswold Nat. F. Club*, vol. xxi, pt. 2, 1922, pp. 157–159.
[2] Rivers Pollution Commission (1868) Sixth Report—' The Domestic Water Supply of Great Britain,' 1874, p. 93 (under ' Unpolluted Water from Deep Wells in the New Red Sandstone ').
[3] *Ibid.*, p. 76 (under ' Water from Shallow Wells in the New Red Sandstone ').

632–633. Malvern.[1]
632. Tunnel, Spring in. Temperature 10.6°C. August 1st, 1873.
633. Green Valley, Upper Spring in. Temperature 11.2°C. August 1st, 1873.

634–635. Birmingham. Welsh Supply, standard analyses.[2]
634. Before screening and filtration.
635. As sent for distribution.

636–638. North Bromsgrove, East Worcestershire Waterworks. From original Burcot borehole in Upper Mottled Sandstone (see p. 136).[3]
636. Sample taken April 1st, 1881. Analyst; Wm. A. Tilden, D.Sc., F.R.S.
637. Do. do. March 29th, 1887. Analyst: C. Meymott Tidy, M.B.
638. Do. do. April 28th, 1887. Analyst: Dr. F. Frankland, F.R.S.

639–640. Old Hill Mines Drainage Scheme, Waterfall Lane Pumping Station Shaft.[4] Analysed, July 21st, 1922. (See page 179; for bacteriological test at same date see p. 180).
639. Top water.
640. From 200 ft. below water-level.

641–644. Stoke Prior. Charford boring for brine (see pp. 82, 180).[5]
641. Sample taken March 7th, 1887. Analyst: J. A. Wanklyn.
642. Do. do. do. do. Analyst: G. H. Ogston.
643. Do. do. March 29th, 1887. Analyst: Dr. C. Meymott Tidy.
644. Do. do. April 28th, 1887. Analyst: Dr. E. Frankland.

645–652. Pershore district. Analyses by E. W. T. Jones, F.I.C., Borough Analyst, Wolverhampton, 1894.[6] (See p. 179).
645. R. Avon at Wyre [Piddle], July 28th. Unfit for drinking. Shows sewage contamination.
646. Do. at Fladbury, do. do. Shows worse sewage contamination.
647. Wyre Brook, August 8th. Unfit for public supply. Exceedingly hard.
648. Walcot Brook, August 8th. Unfit for public supply. Exceedingly hard. Undoubted sewage or animal pollution.
649. Westmancote, Cottage Spring, Aug. 11th. Good, but a little hard.
650. Alnwick Wood Brook. Do. Organic matter appreciable, but of vegetable rather than of animal origin.
651. Kemerton Brook. Do. Good.
652. Elmley Castle, Brook at, do. Shows sewage or animal pollution.

653. Malvern, St. Ann's Well. (From surface of, or fissures in, the Malvernian (Archaean) rocks). Analyst: Dr. Sheridan Muspratt.[7] A more recent report by Dr. J. C. Thresh,[8] states :—" This water is doubtless one of the Softest and Purest Waters found in Nature. It is practically free from Organic Matter, and bacteriologically is of the highest degree of purity. It is practically the same now as when examined by Dr. Muspratt many years ago."

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[1] *Ibid.*, p. 107 (under ' Spring Water from Granites and Gneisses ').
[2] Lees, E. Anthony, in ' Birmingham and Neighbourhood,' *Handbook Brit. Assoc.*, 1913, pp. 188, 198; see also later analyses in the same form in ' Wells and Springs of Warwickshire ' (*Mem. Geol. Surv.*), 1928, pp. 152, 153, and *Annual Reports of the City Analyst.*
[3] Analyses published in *Rep. Brit. Assoc.*, 1889, pp. 72, 73.
[4] Communicated by Mr. S. B. Priest, engineer.
[5] Analyses published in *Rep. Brit. Assoc.*, 1889, pp. 73, 74.
[6] In E. B. Marten's ' Report on the Water Supply for the Town of Pershore,' Aug. 28th, 1894, p. 15; and reprinted in Fosbroke and Duncan's ' Report on the Water Supplies of . . . the Pershore Rural District ' 1910, p. 59.
[7] *Journ. Roy. Dublin Soc.*, vol. ii, 1858–9, p. 205; analysis reproduced in *Rep. Brit. Assoc.*, 1889, p. 74 and elsewhere.
[8] Leaflet issued by Messrs. W. and J. Burrow, Ltd. Sample received by Dr. Thresh on March 19th, 1906.

654. Malvern, Holy Well. Analyst : A. N. Tate, student in Liverpool College of Chemistry.[1] " The water is very pure . . . beautifully clear and transparent and its taste cool and pleasant." Temperature, 46°F. Flow 2 gallons per minute. Sp. gr. 1.0012. Alkaline reaction upon reddened litmus paper.

655. Tenbury ; original Mineral Well. Temperature 48°F. (that of the air being at the same time 38°). Analyst : Mr. West of Leeds, May, 1840.[2]

656. The same. Analyst : Prof. C. Daubeny, 1840.[3]

657. Tenbury ; Crow Orchard or present Mineral Well. Analyst : D. Campbell.[4]

658. Stourbridge. Millmeadow Pumping Station boreholes and wells.[5]

659. Great and Little Hampton. Hampton Spa, Great Hampton. (" The Saline Spring in the new well near Evesham, sunk November, 1821 ") Analyst : Mr. Hume.[6] See also No. 265.

660. Stoke Prior, Stoke Works, Salt Union, Ltd. ' Worcestershire Dairy Salt.' Analyst : G. W. Hedley, M.A., Cheltenham College.[7]

661, 662. Stoke Prior. Brine.[8]

663–668. Droitwich Brine.

663.[9]

664. Anal. L. Horner, 1814.[10]

665. Anal. D. W. Taylor, 1840.[11]

666. Anal. A. B. Northcote, 1855.[12]

667. Anal. Herapath.[13]

668. Anal. Mr. Christie of the Wychia Co., Droitwich.

669, 670. Dudley ; Saltwells Mineral Water. Sample from bottom of well about 36 ft. deep (see p. 108) [in red clay and Downtonian rocks]. Analyst : W. Weldon.[14]

669. Sampled Dec. 2nd, 1808. **670.** Sampled July 18th, 1806.

671. The same. Analyst : Alex. E. Tucker, Birmingham. Sample received June 16, 1900.[15]

ANALYSES IN APPENDIX (p. 215)

672–674. Wolverley Waterworks.

672. (22.i.25). **673.** (27.i.25). **674.** (31.xii.28).

675–676. Oldbury ; South Staffordshire Waterworks Co. There are at least two separate mains of this Company, containing water from different sources ; samples of the water from different mains are here analysed.

675.[16] Tap at Police Station, Church Street. (10.iii.28 ; —).

676.[16] Tap at No. 3, 10-House Row, Salop Street. (6.ii.29 ; 9638).

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[1] Grindrod, Dr. R. B., ' Malvern : Past and Present,' 1865, pp. 12, 13.

[2] Granville, A. B., M.D., F.R.S., ' The Spas of England '—Midland Spas, 1841, table acing p. 324 and pp. 160–163.

[3] *Proc. Ashmolean Soc.*, for 1840, 1841, pp. 16, 17 ; reproduced in Dr. A. W. Davis' ' Essay,' *op. infra cit.*, p. 10.

[4] In Dr. A. W. Davis' ' Essay ' of 1847, p. 9 ; reproduced in Kelly's Directory : Worcestershire, and elsewhere.

[5] Quoted in *Rep. Brit. Assoc.* for 1882, p. 220.

[6] In George May's ' History of Evesham,' 1834, p. 13.

[7] *Proc. Cotteswold Nat. F. Club*, vol. xviii, pt. 1, 1912, p. 21.

[8] In Sir T. E. Thorpe's *Dictionary of Applied Chemistry* ; 661 is from the 1895 edition vol. iii, p. 432 ; 662 is from the 1913 edition, vol. v, p. 11, and is quoted in ' Special Reports on the Mineral Resources of Great Britain,' vol. xviii—Rock Salt and Brine (*Mem. Geol. Surv.*), 1921, p. 12.

[9] *Ibid.*

[10] *Trans. Geol. Soc.*, ser. i, vol. ii, 1814, pp. 107, 108.

[11] In C. Parkinson, *Quart. Journ. Geol. Soc.*, vol. xi, 1884, p. 254.

[12] *Phil. Mag.*, ser. 4, vol. ix, 1855, p. 33 ; quoted in Parkinson, *op. supra cit.*, p. 253.

[13] Quoted by J. H. Hollyer in ' The Natural Brine Baths of Droitwich ' (published for the Corbett Trustees, n.d., and again in 1922), p. 18.

[14] *Journ. Nat. Phil. Chem. and Arts*, vol. xxii, 1809, pp. 276–278.

[15] In *Blocksidge's Dudley Almanack*, 1907, p. 87. The analyst remarks that the water is of a very remarkable character, very similar in composition to that of Woodhall Spa, Lincs.

[16] In Analyses 675, 676 the oxygen absorption figure (opposite *13* in left-hand column) is for a period of 4 hours.

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This list shows the portions of Worcestershire included in each sheet.

QUARTER-INCH MAP.

Old Series sheets : 8, 11, *out of print.*
Revised Series sheets, printed in colours :—
14. Parishes in extreme W. of the county, around Tenbury (1908).
15. The remainder of the county (1910, revised 1922).

ONE-INCH MAP. OLD SERIES SHEETS.

43 N.E. Little Malvern, Malvern Wells, Hanley Castle, Eldersfield (1845, Revised 1855). (Horiz. Sect. 13).
44. Evesham, Upton-on-Severn, Overbury. Bredon Hill, Broadway, Daylesford and most of the Cotteswold parishes (1856). (Horiz. Sect. 59).
54 N.W. Droitwich, Bromsgrove, Clent Hills (1852, Revised 1855, 1898). (Horiz. Sects. 24, 25, 50).
54 N.E. King's Heath (Birmingham), Wythall, Beoley (part).
54 S.W. Worcester, Pershore, Croome D'Abitot, Salwarpe, Inkberrow, Astwood Bank (1854).
54 S.E. Middle and South Littleton, Cleeve Prior, Alderminster, Tredington (S), Newbold-on-Stour (1854).
55 N.W. Tenbury, Bockleton (N) (1850, Revised 1855).
55 S.W. Bockleton (S). (1850).
55 N.E. Kidderminster, Stourport, Bewdley, Knighton, Abberley (1853, Revised 1855). (Horiz. Sect. 50).
55 S.E. Great Malvern, Martley, Clifton-on-Teme, and the country W. of Worcester (1853, Revised 1855). (Horiz. Sect. 13).
61 S.E. N. part of Upper Arley and Wolverley (1852, Revised 1855, 1868).
62 S.W. Dudley, Stourbridge, Oldbury, Halesowen (1852, Revised 1855, 1858, 1885).
62 S.E. Yardley and part of King's Norton (formerly in Warwickshire) (1855, Revised 1886).

ONE-INCH MAP. NEW SERIES SHEETS.

168. Oldbury, Halesowen, Frankley, Northfield and the outskirts of Birmingham. Colour-printed (1924) ; Drift and Solid editions.
217. Overbury, Conderton, Teddington, Sedgebarrow, Broadway, Blockley, Cutsdean, Evenlode. Colour-printed (1929) ; Drift edition.

(' Drift ' editions show in colour the distribution of the Superficial Deposits which rest on the ' Solid ' rocks ; the latter are only coloured where bare of ' drift.' ' Solid ' editions are coloured to show the distribution of ' Solid ' rocks only, whether they are covered by Superficial Deposits or not. The above Old Series sheets are all ' Solid ').

SIX-INCH MAPS :

Of the six-inch maps in the Coalfield areas in the north-east of the county, many have been published in the following forms :—
(a) With engraved geological lines and symbols, 2*s.* 3*d.* each.
(b) The same, but hand-coloured.
Prices of (b) and copies of (a) and (b) may be obtained on application to the Director General, Ordnance Survey, Southampton.
[Certain other six-inch maps in the north of the county have been revised but not published. Coloured copies of these can be supplied at the cost of drawing and colouring on application to the Director, Geological Survey, 28 Jermyn Street, London, S.W.1, who will furnish estimates of cost.]

Horizontal Sections

Sheet (Scale : 6 inches = 1 mile).

13. No. 3. Through Keys [Chase] End Hill [Malvern Hills] and Berrow Hill. 4. From near Ledbury . . . over the north point of Swinyard Hill. 5. From Old Castle through the Herefordshire Beacon. 6. From Brockhill Copse through the Wyche. 7. From near Hall Court through the Worcestershire Beacon.
23. No. 1. North and south from Bellbroughton, through Dudley. . . . (1853, Revised 1865).
24. No. 2. North and south from Lapal [near Halesowen] . . . (1856, Revised to 1865).
25. No. 7. East and west through Kingswinford, Dudley. . . . No. 8. East and west through Wordsley and Langley. No. 9. East and west from Stourbridge, by Cradley and Quinton. No. 10. North and south through Frankley Beeches to the Old Lion Colliery (1853, Revised to 1865).
50. Across the Forest of Wyre, Kidderminster district to the Ashby Canal, near Nuneaton, Warwickshire (1858).
59. From Marlborough Downs to the River Avon, near Great Comberton, crossing . . . Bredon Hill (1860).

Vertical Sections

Sheet

15. No. 3. From the Old Red Sandstone to the rocks of the Malvern Hills.
17. No. 18. Birchyfield Colliery, between Oldbury and Rowley Regis. 22. Section at Tintam Abbey Fireclay Works, near Stourbridge. Comparative sections of the Thick Coal (1853).
18. No. 36. Trial pit at Shaver's End, near Dudley (1853).
94. Sections at Manor Pit. Lafal ; Hawne Colliery ; Wassel Grove, Hagley ; Oldnall, Cradley ; Moat Farm, Oldbury. *In the press.*

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APPENDIX

Additional Information

Bellbroughton.—S. A. Price, Building Surveyor and Sanitary Inspector to Bromsgrove R.D.C., informs me (3.i.29): "This Authority laid a water main from Holy Cross, Clent, linking up with the Stourbridge and District Water Board main at that point, to the village of Bellbroughton in 1924. This was extended in a southerly direction as far as Broomhill Farm, Broom Hill, in 1926. A short length of main has been laid from a point near the Romsley Sanatorium, connecting with the South Staffordshire Waterworks main, southwards to supply the Gutter in Bellbroughton parish, whence it is continued eastwards to supply the 'Boys' Camp' in North Bromsgrove U.D.C.

Wolverley.—Wolverley Waterworks [1] belong to Kidderminster R.D.C. and are situate 40 yds. N.E. of Cookley Bridge over the R. Stour. They supply Cookley, Caunsell and Blakeshall—all in Wolverley parish.

Borehole (in Bunter Pebble Beds) made in 1924. Surface level, 132 ft. above O.D. Depth of borehole, 170 ft.; lined with 15-in. and part 10-in. diameter tubes for a depth of 105 ft.

Rest-level (ascertained by temporary extension of lining tubes) 11½ ft. above top of lining tubes, or 144.5 ft. O.D. Rate of pumping does not exceed rate of overflow.

Yield, 110,000 gallons per day overflow at 1 ft. above ground level. Water pumped to service reservoir (50,000 gallons) on Axborough Hill. Analyses, Nos. 672–674 below.

Kidderminster.—The Victoria Carpet Co. (see p. 114) supply the following particulars of their new boring (1929):—Tube well: diameter 15 in., depth 52 ft., protected by 30½ ft. of 18in. tubes. Boring: depth, 351 ft. (sandstone, some conglomerate, and six bands of marl 1 to 10 ft. thick), water-level when pumping 20,000 gallons per hour, 50 ft. down.

Additional Analyses by C. C. Duncan (see p. 206).

See page 150	672	673	674	675	676
1	—	—	—	Clear	Clear
2	—	—	—	Nil	Nil
3	—	—	—	Nil	Nil
4	Nil	Trace	Nil	Nil	Nil
5	35.0	29.0	32.0	49.0	42.0
6	White	White	White	White	White
7	26.0	23.0	26.0	42.0	36.0
8	N.v.c.	N.v.c.	N.v.c.	N.v.c.	Bng.
9	Nil	Nil	Nil	Nil	Nil
10	3.5	3.5	3.3	22.7	4.4
11	0.0008	0.0008	Nil	Nil	0.0008
12	0.002	0.0011	0.0016	0.0044	0.0044
13	Nil	Nil	Nil	0.013 [2]	0.013 [2]
14	Trace	Trace	Trace	Trace	0.5
15	5.2	5.1	7.2	3.7	8
16	8.0	7.6	4.6	7.7	7
17	—	—	—	Good	Good

[1] Information from D. Llewellyn.
[2] See page 206, footnote 16.

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